TABLE 3.5

VAN DYKE

1982

EFFECTS OF DELAYED SHIPMENT ON EGG VIABILITY

River	Date Taken	Date Received	Day (s) Late	Number of Eggs	Percent Viability	Control Viability*	Percent Differences In Viability
Pamunkey	4/19	4/21	1	177,200	78.8	80.0**	1.2
Pamunkey	4/25	4/28	2	241,000	62.0	71.9	9.9
Pamunkey	4/26	4/28	1	212,000	28.6	71.9	43.3
Columbia	6/16	6/18	1	≅262,000	0	31.7	31.7
Columbia	6/21	6/22 (p.m.)	1/2	1,708,000	27.9	31.9***	4.0

*Control viability is the average viability of the shipment immediately prior to and following late shipment.

**Only the following shipment was used as the control.

**Control was a group collected on the same date but shipped 12 hours earlier.

TABLE 3.6

SUMMARY OF VAN DYKE PRODUCTION

1976-1982

	1976	1977	1978	1979	1980	1981	1982
Volume of Eggs Received (liters)	120.3	145.8	381.2	164.8	347.6	286.0	624.3
Number of Eggs Received (millions)	4.0	6.4	14.5	6.4	12.5	11.6	25.9
Egg Viability (percent hatch)	52.0	46.7	44.0	41.4	65.6	44.9	35.7
Number of Viable Eggs (millions)	2.1	2.9	6.4	2.6	8.2	5.2	9.2
Shad Stocked							
Fry (up to 1")	518,000	968,901	2,124,000	629,500	3,526,275	2,029,650	5,018,800
Fingerling (1" and larger)	266,000	34,509	6,379	34,087	5,050	23,620	40,700
TOTAL	784,250	1,003,410	2,130,379	663,587	3,531,325	2,053,270	5,059,500
Percent of Eggs Received which were eventually stocked	19.4	15.9	14.0	10.4	28.3	17.7	19.6
Percent of Viable Eggs which were eventually stocked	37.3	34.2	33.0	25.1	43.1	39.3	54.8

Total Shad Stocked from 1976 to 1982 - 15,225,400

TABLE 3.7

VAN DYKE HATCHERY

SUMMARY OF STOCKING ACTIVITIES

1982

FRY STOCKINGS

Date	Age (Days)	Number
05/27	17-28	813,700
05/28	18	145,300
05/31	18	18,200
06/08	32	54,500
07/07	14-16	395,500
07/13	19-20	324,200
07/14	19-20	711,600
07/15	18-19	571,300
07/16	19-20	385,100
07/17	16	613,400
07/19	19	224,800
07/20	18	261,200
07/22	16	500,000
	TOTAL	5,018,800

FINGERLING STOCKINGS

Date	Age (Days)	Size (Inches)	Number
07/27	91	2.0	375
07/28	92	2.0	1,300
08/12	52	1.1	500
09/02	56	2.0	20,000
09/03	57	1.0	3,300
09/08	62	1.2	6,300
09/09	63	1.2	3,975
09/13	67	1.3	600
09/15	69	1.4	4,000
09/27	-	3.9	350
		TOTAL	40,700

TABLE 3.8

VAN DYKE

1982

EGG VIABILITY TEST

THE VIABILITY OF AMERICAN SHAD EGGS UNDER ROLLING AND NON-ROLLING CONDITIONS

Eggs Under Rolling Incubation Conditions

Experimental Unit Number	Number Of Eggs	Number Viable	Percent Viable
1	2,000	1,611	80.6
2	2,000	1,671	83.6
3	2,000	1,718	85.9
4	2,000	1,766	88.3
5	2,000	1,593	79.7
6	2,000	1,256	62.8

Total Number of Eggs: 12,000
Total Number of Viable Eggs: 9,615
Mean Number of Viable Eggs: 1,603
Standard Deviation: 182
Percent Viable: 80.2

Eggs Under Non-Rolling Incubation Conditions

Experimental Unit Number	Number Of Eggs	Number Viable	Percent Viable
1	2,000	1,616	80.8
2	2,000	1,330	66.5
3	2,000	1,609	80.5
4	2,000	1,581	79.1
5	2,000	1,585	79.3
6	2,000	1,387	69.4

Total Number of Eggs: 12,000
Total Number of Viable Eggs: 9,108
Mean Number of Viable Eggs: 1,518
Standard Deviation: 126
Percent Viable: 75.9

TABLE 3.9

VAN DYKE

1982

VIABILITY OF AMERICAN SHAD EGGS UNDER ROLLING AND NON-ROLLING INCUBATION CONDITIONS - PRODUCTION

Dates Of Incubation	Treatment (Rolled-R Non-Rolled-NR)	Number Of Eggs	Number Of Viable Eggs	Percent Viable
4/21-4/30/82	NR	100,300	81,600	81.4
	R	73,100	63,400	86.7
	NR	59,100	40,900	69.2
	R	88,800	71,300	80.3
	NR	88,400	68,400	77.4
4/22-5/1/82	NR	106,100	78,500	74.0
	R	105,400	73,500	69.7
	NR	101,200	72,200	71.3
4/28-5/7/82	NR	132,800	92,000	69.3
	NR	54,400	29,900	55.0
	R	53,800	27,600	51.3
	NR	45,700	41,900	91.7
4/29-5/8/82	NR	71,600	53,200	74.3
	R	63,000	44,800	71.1
	NR	100,900	69,600	69.0
	R	89,600	66,200	73.9
	NR	82,500	51,800	62.8
	R	79,700	50,700	63.6
	NR	82,400	50,200	60.9
	R	82,400	59,000	71.6
	NR	84,600	34,800	41.1
	R	84,600	27,300	32.1
4/30-5/10/82	NR	72,000	55,200	76.7
	R	72,700	57,400	79.0
	NR	76.300	59,600	78.1
	R	75,000	62,400	83.2
5/1-5/11/82	NR	60,400	48,600	80.5
	R	60,400	49,700	82.3
	NR	111,700	72,400	64.8
	R	111,700	76,100	68.1
	NR	98,200	73,900	75.3
	R	98,200	75,900	77.3

TABLE 3.10

VAN DYKE

1982

TOTALS FOR VIABILITY OF AMERICAN SHAD EGGS UNDER ROLLING AND NON-ROLLING INCUBATION CONDITIONS - PRODUCTION

Eggs Under Rolling Incubation Conditions

Total number of eggs:	1,138,400
Total number of viable eggs:	805,300
Mean number of eggs incubated per hatching unit:	81,314
Mean number of viable eggs per hatching unit:	57,521
Mean percent viability:	70.7

Eggs Under Non-Rolling Incubation Conditions

Total number of eggs:	1,528,600
Total number of viable eggs:	1,074,700
Mean number of eggs incubated per hatching unit:	84,922
Mean number of viable eggs per hatching unit:	59,706
Mean percent viability	70.3

TABLE 3.11a

VAN DYKE

1982

HANDLING MORTALITY STUDY

Density: 2500 fish/tank (2.3 fish/liter)

	Daily Mortality		
Tank	#1	#2	#3
1	1,204	531	19[illegible]
2	981	321	150
3	1,518	273	118
Total Mortality (Daily)	3,703	1,125	460
Mean Mortality (Daily)	1,234	375	153
Mean Percent Mortality (Daily)	49	15	6

Mean 72 hour Mortality: 71%

Density: 500 fish/tank (.5 fish/liter)

	Daily Mortality		
Tank	#1	#2	#3
1	114	101	21
2	174	79	32
3	273	61	22
Total Mortality (Daily)	561	241	75
Mean Mortality (Daily)	187	80	25
Mean Percent Mortality (Daily)	37	16	5

Mean 72 hour Mortality: 58%

TABLE 3.11b

VAN DYKE

1982

HANDLING MORTALITY STUDY

Density: 6500 fish/tank (5.9 fish/liter)

	Daily Mortality		
Tank	#1	#2	#3
1	1,744	275	220
2	3,015	641	236
3	3,719	1,056	496
Total Mortality (Daily)	8,478	1,972	952
Mean Mortality (Daily)	2,826	657	317
Mean Percent Mortality (Daily)	44	10	5

Mean 72 hour Mortality: 58%

Density: 4500 fish/tank (4.1 fish/liter)

	Daily Mortality		
Tank	#1	#2	#3
1	1,657	686	274
2	1,842	491	394
3	2,460	368	342
Total Mortality (Daily)	5,959	1,545	1,010
Mean Mortality (Daily)	1,986	515	337
Mean Percent Mortality (Daily)	44	11	7

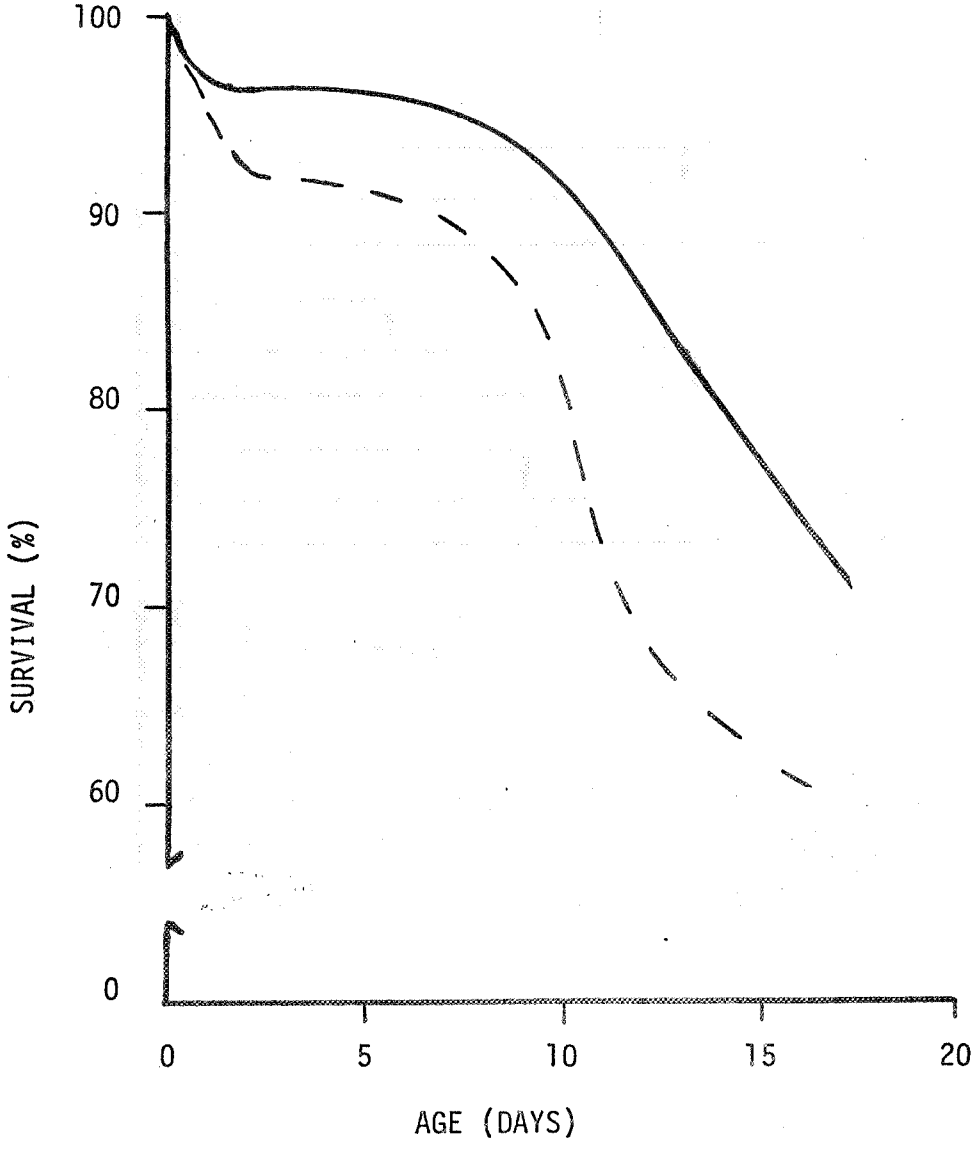
Mean 72 hour Mortality: 63%

FIGURE 3.1

VAN DYKE

1982

FRY SURVIVAL



——— Fry of Virginia River Origin

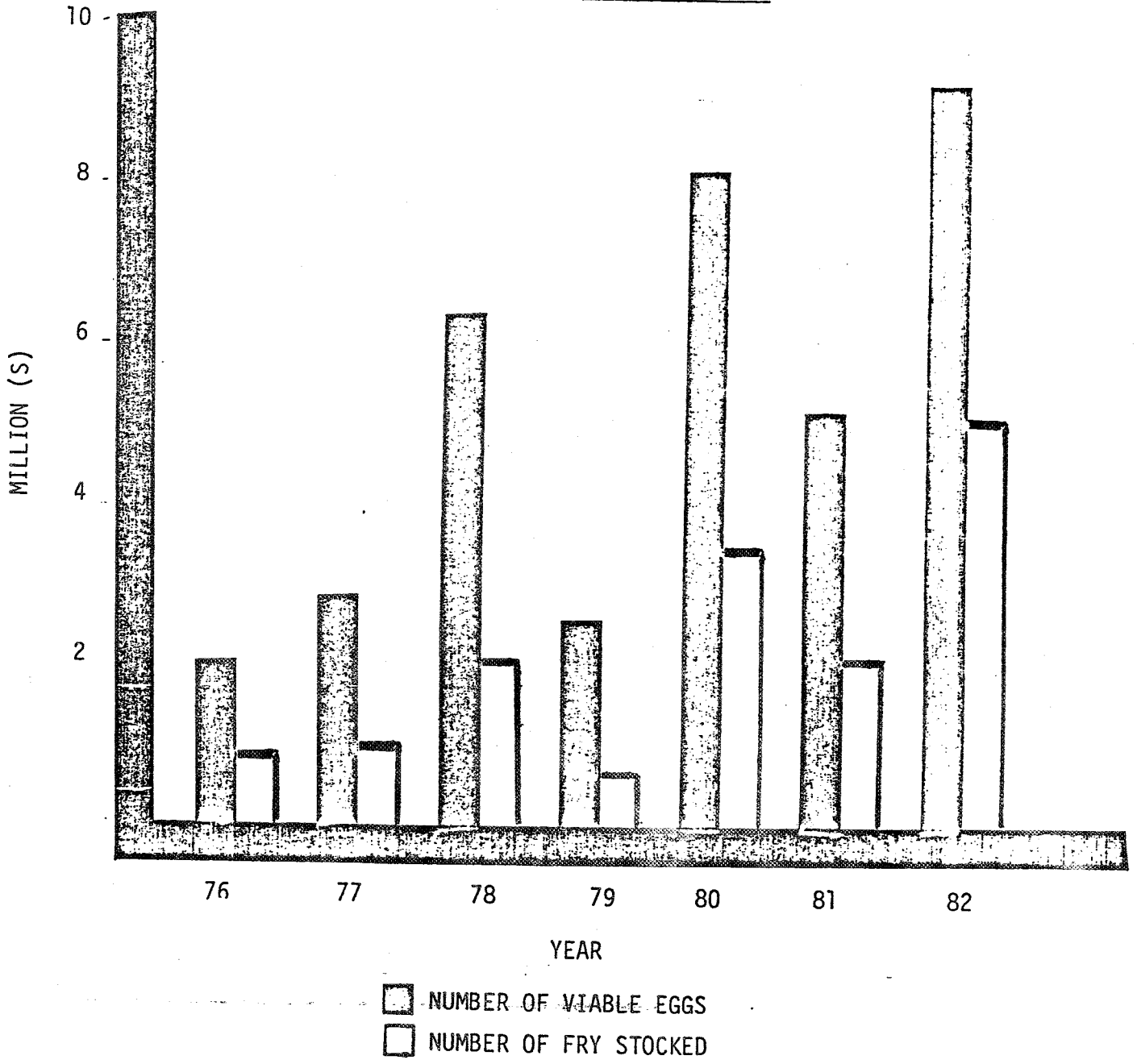
– – – – Fry of Columbia River Origin

FIGURE 3.2

VAN DYKE

NUMBER OF VIABLE EGGS

STOCKED AS FRY



JOB IV. EVALUATION OF AMERICAN SHAD STOCKING EFFORTS

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INTRODUCTION

The stocking program of adult American shad from out-of-basin sources (Job I) and from the Conowingo fish lift (Job VI) are intended to produce juvenile shad from natural reproduction. The egg collection program (Job II) supports the Pennsylvania Fish Commission intensive culture effort at the Van Dyke hatchery producing additional juvenile shad for the Susquehanna River system. The common goal of all of these efforts is to create a "strain" of American shad, imprinted to the Susquehanna, which will migrate to sea and return several years later as adults to spawn. Any future construction of permanent fish passage facilities at the four lower river hydroelectric projects is dependent upon success of these efforts.

The 1982 evaluation program was similar to that of 1981. The program is designed to provide a qualitative assessment of the success of the hatchery and adult stocking programs. Specific objectives are to determine if transferred adults spawned successfully; juveniles from the upper Susquehanna grew and migrated downstream; and, fry and fingerlings from the hatchery grew normally and moved out of the Juniata River as water temperatures cooled.

Another aspect of the program in 1981 and 1982 was an assessment of the availability of juvenile shad in the lower Susquehanna River from Conowingo Dam to Harrisburg. Shad taken from this area are assumed to be from both the culture operation and natural spawning of adults

transferred from Conowingo and out-of-basin sources. The purpose of this evaluation is to determine whether juveniles are surviving transit past hydroelectric projects, and the progress of shad migration through Susquehanna River impoundments.

The 1981 program was successful in identifying the natural spawning of adults in the upper Susquehanna River and the downstream movement of juveniles in the mainstem and Juniata River. Growth in both stocks was considered seasonally normal. Juvenile shad were also collected at the hydroelectric projects in the lower river in 1981. The main difference in the program in 1982 is the requirement to sample the upper reaches of the North Branch in New York to confirm spawning of Hudson River transplants, and a more thorough assessment of impingement of juvenile shad at lower river hydroelectric projects.

A. EVALUATION OF SPAWNING SUCCESS OF ADULT SHAD

In 1982, National Environmental Services, Inc. (NES), under contract to SRAFRC, conducted a sampling program for young American shad on the upper Susquehanna below the release sites for adult shad transplanted from the Hudson and Connecticut rivers. NES worked cooperatively with various resource agency members of SRAFRC throughout the program.

Sampling locations were selected utilizing the experience gained in 1981, and areas where Carlson found juvenile shad during his studies in the mid-1960's. The sampling area was expanded northward compared to 1981 because of the stocking of Hudson River fish at Owego, NY.

Initial sampling was done in the river reach from Owego to Nichols, NY, and from Nichols to Sayre on the NY/PA border (Figure 1). Other sampling areas for Hudson River fish were from Towanda to Laceyville, PA, includ- Terrytown and Wyalusing.

Evaluation of reproduction from Connecticut River shad stocked at Tunk- hannock began near Harding/Duryea and continued progressively downstream at West Pittston, Wilkes-Barre, Glen Lyon and Beach Haven. Several efforts were made to collect shad in front of the intake structure of PP&L's new Susquehanna Steam Electric Station near Beach Haven.

Sampling Schedule and Methods

Sampling for juvenile American shad began with a cooperative effort by NES and the New York Department of Environmental Conservation at Owego, on August 26 (Table 1). The program continued through September and was terminated on September 30. Although continuation of the field survey was deemed impractical, NES maintained contact with Ichthyological Associates at Berwick in the event that shad were taken in their ongoing sampling.

Various gear was employed in the juvenile sampling program. This included electrofishing, cast nets and seines. Electrofishing gear consisted of boat mounted and backpack units. NES personnel worked with IA between Harding and Berwick using their boat electrofishing equipment. At other times an AC/DC backpack unit (100-150 volts AC) equipped with two 5-ft. probes was utilized. Netting of 1/8-in. mesh was sewn to the hoop of one probe to capture fish which may have been shocked. This unit was

modified to be used from a boat, or carried. Cast nets of 7 and 8-ft. diameter were also used in areas that were not feasible for electrofishing or seining. Because seines were the most successful gear for sampling juvenile shad in 1981, they were used extensively in 1982. Two seines used measured 100'x 4' with ¼" mesh and 150' x 6' with ½" mesh. The nets were used interchangeably depending upon topography of the area and water depth. Sampling operations were conducted from morning until dark and approximately 10-15 mile sections of the river were sampled each day.

Results

No juvenile American shad were taken on the upper Susquehanna River in 1982. This compares with 32 fish taken in 1981. Throughout the evaluation program numerous young-of-year gizzard shad were collected. These were taken mostly in deep pools and portions of the river where American shad were taken in 1981. All gizzard shad were taken by seine with the furthest upstream capture coming from Terrytown, PA.

B. EVALUATION OF AMERICAN SHAD STOCKED FROM VAN DYKE HATCHERY

In 1981, an extensive evaluation survey was conducted in the Juniata River by NES to determine the abundance, distribution and downstream migration patterns of shad released as fry from the Van Dyke Hatchery at Thompsontown, PA. Since most shad were collected near the mouth of the river at Amity Hall, the 1982 effort was streamlined to only sample that one site.

Methods

Sampling with seines was scheduled for the period September through mid-October on a bi-weekly basis. Since the evaluation was qualitative in

scope, it was recognized that the Juniata River effort would terminate once a firm confirmation of juvenile shad growth and downstream movement was achieved. As scheduled the effort would involve personnel from PFC and USFWS with NES providing a "training day" early in the program.

Seine sampling occurred at Amity Hall on September 14 using NES's 150' x 6' bag seine with ½" mesh; and on September 30 using PFC's 75' x 6' seine with ¼" mesh.

Results

Five seine hauls were made on September 14 immediately downstream from the boat ramp at PFC's Amity Hall Access Area. A total of 28 shad in a size range of about 65-90mm fork length were collected, mostly from a cove area furthest from the ramp. On September 30, PFC and USFWS personnel made two seine hauls at the same cove area and collected 131 juveniles ranging in size from 70 to 105mm. D.C. electroshocking at the same site produced no shad.

Based on results of this 2-day effort, it was decided to discontinue collecting efforts on the Juniata River. Growth and downstream movement of juveniles had been confirmed and killing additional fish would not produce benefits to the program. Blood samples from 25 fish were taken and sent to the National Fish Health Laboratory along with frozen carcasses for viral analysis.

C. EVALUATION OF JUVENILE SHAD MOVEMENT IN THE LOWER RIVER

The third phase of the evaluation program is designed to determine if shad have moved to the lower Susquehanna River and whether or not they are

progressing through the hydroelectric impoundments on their seaward journey. Any shad collected between Conowingo Dam and the confluence of the Juniata River at Clarks Ferry must be considered to be of undetermined origin relative to Jobs I, III and VI. In this lower stretch of the mainstem river, shad from all three sources intermingle and differentiation is not possible at this time. Shad collected below Conowingo Dam may be the result of upstream stockings or progeny from natural reproduction in the tidal Susquehanna River. NES was responsible for coordinating all efforts upstream from Holtwood Dam and Radiation Management Corporation (RMC) collected specimens below Holtwood.

Methods

NES set up a monitoring system at Safe Harbor and Holtwood hydroelectric stations to determine when shad reached lower river dams. NES personnel visited each facility and met with project staff to discuss identification of juvenile American shad. Samples of American and gizzard shad were provided for comparison. Arrangements were made with project personnel to examine travelling screens (Holtwood) and strainers (Safe Harbor) on a daily basis during September through November. Jars and preservative were provided by NES. Specimens were measured, preserved in 10% formalin and the collection date and water temperature were recorded. Ichthyological Associates, working cooperatively with NES, agreed to report any shad taken during their studies related to the ecology of the river in the vicinity of Three Mile Island.

The monitoring system discussed above was supplemented with field operations by NES. Sampling was conducted in the forebay areas of Holtwood, Safe

Harbor and York Haven dams. Gear included electroshocker, gill nets and cast nets. Various days were set aside in September, October and November for sampling. Seven days of effort were spent at Holtwood, four at Safe Harbor, and two at York Haven. Hydroproject personnel notified NES of any visual observation of juvenile shad in their forebays.

RMC evaluation efforts below Holtwood can be broken into three categories: impingement on travelling screens at Peach Bottom; impingement on cooling water strainers at Conowingo; and field sampling above and below Conowingo Dam. Fishes collected off the screens at Peach Bottom were examined each Monday, Wednesday, and Friday between October 20 and December 10. Virtually all fishes impinged during the period were accounted for. Cooling water strainers at Conowingo Hydroelectric Station were sampled for American shad each Friday between October 22 and December 10.

Gill netting was attempted in the Conowingo forebay area on two occasions using experimental nets made up of 25 foot panels at meshes graduated from ½ to 1½ inches. They were fished at the surface and at 10-ft. depth. Bad weather conditions precluded further sampling above Conowingo. RMC is conducting extensive collecting efforts below Conowingo to determine the effect of a continuous flow on fishery populations. This relates to Article 34 of PECO's operating license for the project. Gear used includes gill nets and electrofishing and the area sampled extends to tidewater.

Results

Monitoring of screens at Holtwood and strainers at Safe Harbor began on September 1. Examination of impingement occurred on a daily basis through November and resulted in the collection of 36 juvenile American shad.

All shad were taken at Safe Harbor (Table 2) between October 25 and November 24. The maximum taken in one day was 13 on November 8. Shad ranged in length from 85 to 116 mm and were taken on 13 individual dates at water temperatures ranging from 46°to 57°F.

The first juvenile shad taken in the lower Susquehanna River was by Ichthyological Associates on September 29. This was a 117 mm specimen collected by electrofishing in the vicinity of Three Mile Island. IA also collected an additional seven shad in 5 sampling days between October 7 and 21. These specimens varied in size from 97-103 mm and were collected near TMI at water temperatures of 48-69°F.

Gill netting by NES at York Haven (August 23 and October 19), Safe Harbor (September 13), and Holtwood (October 4 and November 11) did not result in capture of juvenile shad. NES did collect 46 shad on November 11 by use of cast net in the forebay of the Holtwood project. Many more shad could have been collected as "hundreds" were observed. Those taken ranged in size from 63-108 mm and the water temperature was 51°F (Table 3).

One unique observation of shad was brought to the attention of PFC Waterways Patrolman Ken Pritts. Anglers fishing below York Haven Dam near Falmouth reported hundreds of seagulls feeding on schools of shad. At least one shad was regurgitated by an angler caught walleye. At the report of this observation, NES contacted York Haven Dam and they related that thousands of shad were observed dimpling on the water surface early and late in the day of October 18. Gill netting on the 19th was unsuccessful and it was learned that floodgates were opened on the 18th to pass shad downstream.

No American shad were collected by gill netting above Conowingo Dam or impinged on the cooling water intake strainers at Conowingo. Only one juvenile shad was collected below the dam - taken by gill net near Port Deposit in mid-November. The Maryland DNR reported one additional shad being taken in their survey at the mouth of the river in late October. These two fish were collected in/or near tidal water and may be progeny of lower river spawners, or from upstream stocking activities.

Collections at Peach Bottom Atomic Power Station were much more rewarding. The first American shad was collected on October 29 at a water temperature of 55°F and as of December 3, 108 juveniles were reported from this source (Table 4). These fish ranged in size from 73 to 130 mm with one specimen measuring 154 mm. During the week of December 6, shad were still being collected and water temperature was in the lower 40's. Predominant among fish impinged at Peach Bottom and Conowingo were young of the year gizzard shad.

DISCUSSION

A. Upstream Evaluation

Approximately twice as many live adult shad were transported to the upper Susquehanna River in 1982 as compared to 1981. Assuming that these fish survived and spawned in similar proportions each year, we would have expected to collect juvenile shad more frequently and in greater abundance in upstream sampling areas in 1982. Failure to collect even a single shad may indicate that no successful spawning occurred. Before such contention can be adopted however, it is necessary to place variables between the two program years in perspective.

In 1981, 1,486 adult shad were hauled from the Connecticut River at Holyoke to Tunkhannock, PA, and known mortalities amounted to 22%. The Connecticut River experienced a "normal" flow year in 1981 and fish being transported were noted as being of good quality.

In 1982, 3,453 adults were transported from the Hudson River (1,166) and Connecticut River (2,287). Hudson River fish were apparently healthy and vigorous, being collected in haul seines, and known mortalities were 14%. Connecticut fish were of an apparent inferior quality. Extremely high flow conditions in the vicinity of Holyoke and mechanical damage due to delayed holding, sorting, and loading may have produced a poor product from the Connecticut River in 1982. Known mortality of fish transported amounted to 31%. New England biologists assessing relative abundance of juvenile shad in the Connecticut have indicated that the 1982 year class was very weak.

Another variable to be looked at is the relative effort expended on upstream sampling for juveniles in 1981-1982, and the frequency of capture in 1981. This years program was intentionally limited since insufficient funds were available after Jobs I - III to mount a more thorough assessment. In 1981, sampling with seines and electrofishing gear occurred on 27 days between July 23 and October 21. Of the 32 shad collected that year, 21 were taken at Wilke-Barre on August 28-29; 9 at Beach Haven during 3 days in September; and 2 at Mifflinville (see NES report for 1981). In 1982, effort amounted to 13 days, covering the period August 26-September 30, and was spread over twice as much area to include New York waters. Therefore, although we expected to confirm spawning upstream this year, the lack of juveniles in our 1982 collections does not, by itself, indicate spawning failure.

B. Juniata River Evaluation

The Van Dyke hatchery produced and stocked 5 million shad fry in 1982 compared to 2 million in 1981. Assuming that similar survival, growth and downstream migration occurred both years, we expected that juvenile shad in the lower Juniata River would be considerably more abundant and available to our gear in 1982.

Although much more sampling was done in 1981, a fair comparison would look at similar effort during a given period of time. In 1981, seine surveys were conducted at Amity Hall on September 3, 29, and 30. Shad were collected each day and the total catch for the period was 25 fish. Water temperatures were 61-72°F. Since only seven seine hauls in two days in September, 1982 produced 159 fish (similar temperatures), it appears that increased fry stocking resulted in marked increases in juveniles as expected. The fact that 1982 fish were considerably smaller than those of 1981 (85 mm vs. 120 mm) may reflect the fact that most fry stocked in 1982 were of Columbia River origin (i.e. late eggs), or that river temperatures during the summer growth period were depressed.

C. Lower River Evaluation

As mentioned earlier, shad juveniles from all three sources (upstream adult transplant, hatchery, Conowingo transplant) intermingle in the lower Susquehanna River survey area and are not readily distinguishable. Based upon increased stocking of fish in all areas, we expected juveniles to be more numerous in the lower river in 1982 compared to 1981.

In 1981, 49 juvenile shad were collected between October 7 and November 23 at water temperatures of 45 - 60°F as follows:

9	TMI	shocking	Oct. 7-28
2	York Haven	"	Oct. 29
17	Safe Harbor	strainer	Oct. 9-31
15	Holtwood	cast net	Oct. 19-Nov. 20
6	Holtwood	screens	Nov. 2-4

In 1982, with similar effort, 8 shad were taken at TMI, 36 at Safe Harbor, and 46 at Holtwood. Even recognizing that cast net sampling tends to occur only when fish are seen or presumed to be in the immediate area, it still appears that more juveniles were moving downstream in 1982. The Peach Bottom collections are the closest measure we have for determining relative abundance. All fishes impinged on the cooling water intake screens were accounted for during the fall outmigration in 1981 and 1982. In 1981, sampling occurred daily from October 28 through December 2 at water temperatures of 43 - 53°F. A total of 7 juvenile American shad were collected. In 1982, 108 juveniles were taken between October 29 and December 3 at similar water temperatures. From this it appears that there were fifteen times more shad in the Conowingo Pond near Peach Bottom in 1982 compared to 1981. These data are not necessarily comparable, however, due to the fact that other variables such as river flow and cooling water demand affect impingement.

Failure to collect shad at the Holtwood screens in 1982 may be related to the unusually low flow conditions (1/3 of normal for October-November). The ½-inch screens cover intakes for once-through cooling water for the steam electric plant only. The intake volume of 76 million gallons per day (117 cfs), amounts to only 4% of the continuous flow through the hydroproject (3,000 cfs) and 0.4% of maximum generating capacity.

Thus, fish were by-passing the screens and moving with the main flow of river water through the turbines. Strainers at Safe Harbor are located in the turbine scroll cases and fishes are much more susceptible to collection in this area due to concentration.

The Conowingo Dam situation is similar to that of Safe Harbor though no continuous flow is provided at that project after September 15. One American shad was collected at Conowingo Dam in 1981. Sampling below Conowingo under almost any power generation mode is nearly impossible. Sampling with nets and shockers during shutdown periods is not expected to yield many shad since they would have been pushed out of the tailrace area with generation flows.

CONCLUSIONS

1. Spawning of transplanted adult American shad from Conowingo Dam and out-of-basin sources was not confirmed in 1982.
2. Poor condition of Connecticut River shad and infrequency of juvenile sampling efforts may account for failure to collect young shad in the North Branch.
3. Juvenile shad produced at PFC's Van Dyke hatchery survived, grew, and migrated downstream in the Juniata River. They were considerably more abundant in 1982 compared with 1981, but the average size of fish was smaller.

4. Juvenile shad , probably from all sources, appeared to be more abundant in 1982 in the lower river from Conowingo Dam to Three Mile Island.

5. Juvenile shad migrate downstream as water temperatures cool in the autumn, and some proportion of the population survives transit through hydroproject turbines and power pools.

6. Collections at Peach Bottom Atomic Power Station can be used cautiously for determining relative abundance of juvenile shad for 1981 and 1982. Our information indicates that there were 15 times more American shad in the vicinity of that project in 1982.

7. We cannot document whether shad produced in the Susquehanna River system have successfully completed migration to the Chesapeake Bay in 1982.

Figure 4.1 LOCATION MAP OF SHAD STOCKING AND EVALUATION SITES IN THE SUSQUEHANNA RIVER BASIN - 1982.

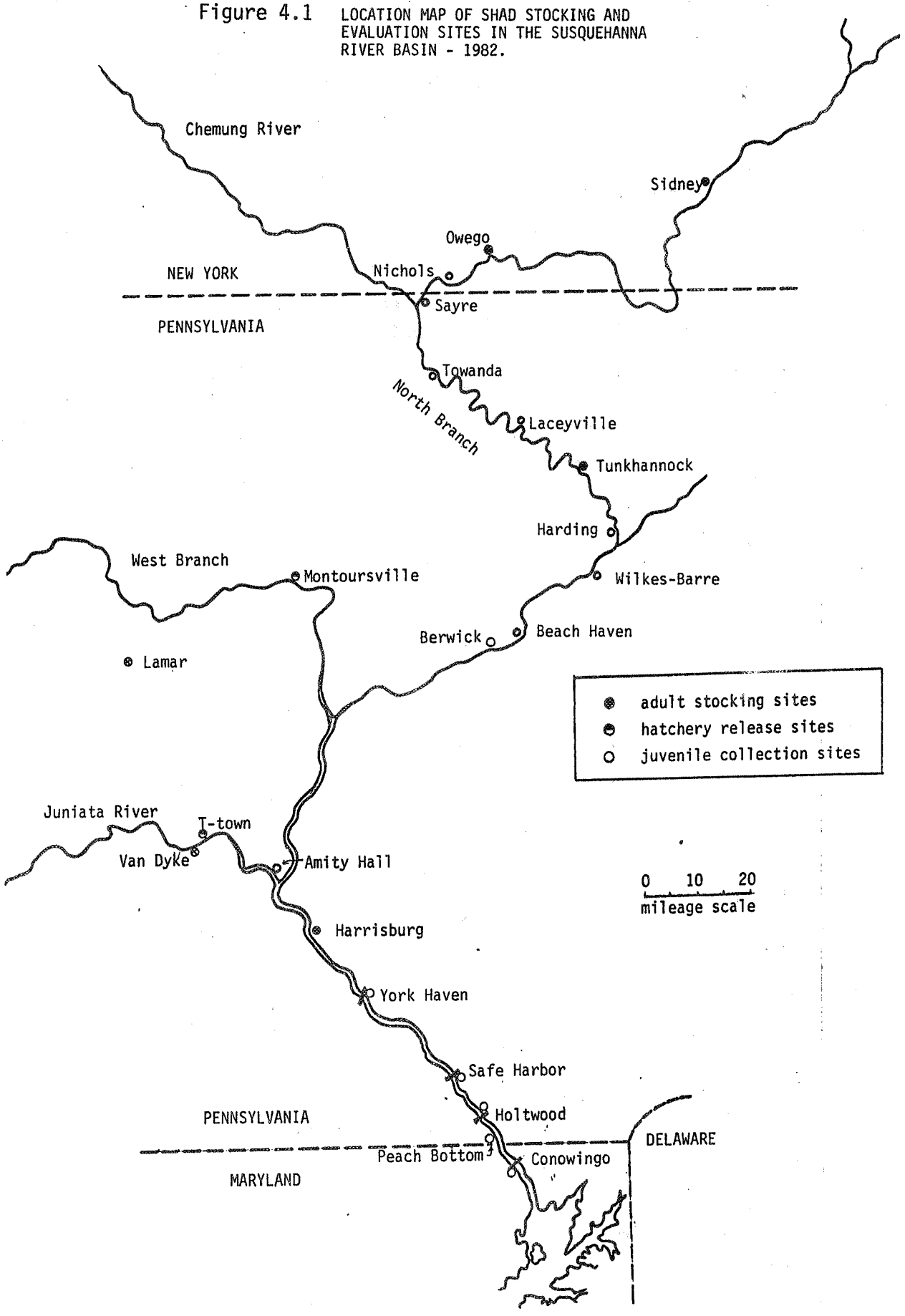

TABLE 4.1 Dates and locations of sampling efforts for juvenile shad on upper Susquehanna River, Owego NY to Berwick, PA.

NORTH BRANCH

DATE		WATER TEMP. (°F)	LOCATION
AUGUST	26	77	Owego, NY
	27	76	Nichols/Sayre
	30	75	Pittston
	31	74	Coxton
SEPTEMBER	1	74	Wilkes-Barre
	2	75	Wilkes-Barre
	3	73	Beach Haven
	15	67	Beach Haven
	15	64	Wyalusing
	27	60	Clark-Summit
	28	58	Terrytown
	29	57	Lacyville
	30	56	Beach Haven

TABLE 4.2 Capture Information on Juvenile American Shad Collected in the Lower Susquehanna River above Holtwood - 1982.

Date	Number	FL(mm) mean & range	Location	Capture Method	Water Temp.° F
Sept. 29	1	117	TMI	shock	66
Oct. 7	1	98	TMI	shock	69
Oct. 12	3	97-105	TMI	shock	68
Oct. 14	1	103	TMI	shock	59
Oct. 20	1	75	TMI	trap net	56
Oct. 21	1	126	TMI	shock	58
Oct. 25	7	87-103	Safe Harbor	strainer	57
Oct. 27	2	85-105	"	"	54
Oct. 28	1	105	"	"	53
Oct. 29	2	92-104	"	"	52
Nov. 3	1	127	"	"	55
Nov. 4	1	86	"	"	56
Nov. 8	13	91-115	"	"	56
Nov. 10	1	110	"	"	53
Nov. 11	46	63-108	Holtwood	cast net	51
Nov. 14	1	95	Safe Harbor	strainer	50
Nov. 15	2	103-116	"	"	49
Nov. 18	2	98-111	"	"	46
Nov. 23	2	95-110	"	"	47
Nov. 24	1	92	"	"	48

TABLE 4.3 Length Frequency Distribution of Juvenile American Shad Collected on Lower Susquehanna River Between Holtwood and Three Mile Island during Fall, 1982.

Fork Length (mm)	Sept. 29-Oct. 7	Oct. 8-14	Oct. 15-21	Oct. 22-28	Oct. 29-Nov. 4	Nov. 5-11	Nov. 12-18	Nov. 19-25	TOTALS
61-65						1			1
66-70						1			1
71-75			1						1
76-80					1				1
81-85				1		2			3
86-90				1		4			5
91-95		1		2	1	19	1	2	26
96-100	1	1		3		8	1		14
101-105		2		3	1	18	1		25
106-110						5		1	6
111-115						2	1		3
116-120	1						1		2
121-125									0
126-130			1		1				2
TOTALS	2	4	2	10	4	60	5	3	90

Mean Length = 99.5 mm

Table 4.4. Capture information for juvenile American shad at Peach Bottom Atomic Power Station, 1982.

Date	Hours collected at Units 2 and 3	Intake Temp. (F)	Number of shad
10/20	47.8	62.0	-
10/22	48.9*	59.5	-
10/25	72.0	55.0	-
10/27	47.9*	55.5	-
10/29	47.6	55.0	1
11/1	72.4	61.5	-
11/3	48.0	60.0	-
11/5	49.8*	60.0	-
11/8	70.7*	54.5	9
11/10	47.5	54.0	5
11/12	48.8	54.5	9
11/15	73.0	50.9	17
11/17	48.0	48.2	27
11/19	46.8	48.8	14
11/22	77.0	46.6	7
11/24	42.5	49.5	1
11/29	120.0	46.5	5
12/1	48.8	46.5	11
12/3	47.7	45.0	2
12/6	71.8	50.5	3
12/8	48.3	49.0	2
12/10	48.0	46.0	1
12/13	74.0	43.0	1
12/15	46.8	42.0	-
Totals	1394.1 hrs.		115

* average hours for both Units

JOB V. LAMAR FISH CULTURAL DEVELOPMENT CENTER INVESTIGATIONS

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INTRODUCTION

The National Fish Hatchery Development Center Program was created by the U. S. Fish and Wildlife Service in 1966 to servc an intermediary function between research and field stations and to assure that the results from Service research laboratories were further tested or refined prior to application to hatchery operations. The Lamar Fish Cultural Development Center is one of five such centers. The original efforts of the Lamar FCDC were directed primarily to hatchery effluent monitoring and pollution abatement; distribution systems evaluation and improvement; and evaluating, refining, or innovating labor-saving devices or techniques applicable to fish culture. During 1977, Lamar Development Center efforts were redirected to work dealing with biological problems of fish culture. Studies intially involved intensive rearing techniques for American shad and cool water fish species.

In 1979, restoration of American shad to the major rivers of the Northeast was identified as a high-ranking Important Resource Problem (IRP) by the Fish and Wildlife Service. The Service, along with other natural resource agencies, was already involved in the Susquehanna River anadromous fish restoration effort. It was recognized that the development of intensive culture techniques for rearing juvenile shad, adequate artificial diets, transportation methods, and a satisfactory method of mass-marking juvenile

shad could play an important role in restoration efforts. Various shad culture, feeding, tagging, and transportation studies were conducted by the Lamar FCDC over the past five years.

Lamar works closely with research personnel from the Pennsylvania Fish Commission and particularly with staff at the Van Dyke Hatchery. This report summarizes activities conducted during 1982, though several investigations were initiated in prior years.

MARKING JUVENILE SHAD

A means of marking juvenile American shad is needed for evaluation of shad rearing and stocking programs and for biological studies. A permanent mark to persist during the entire life of the fish would be most desirable and could be used to identify the origin of mature adults returning from the sea. A mark of shorter duration can be useful, however, for studies such as evaluation of survival and progress downriver of hatchery-reared juveniles or passage of outmigrant juvenile shad through turbines, spillways, or other facilities.

A marking study was initiated in FY-82 with Dr. Doug Anderson of the National Fish Health Research Laboratory to study the immune response of American shad to various antigens. The study is designed to help determine if immunization could be used as a tool to label or tag fish and also if American shad can be immunized against disease.

American shad ($\bar{X}$ = 82.8 mm and 4.5 g) were immunized by injection and/or flush exposure to antigen suspensions of dinitrophenol keyhole limpet hemocyanin (DNP-KLH), Yersinia ruckeri O-antigen extraction from serotype II, and a Y. ruckeri commercial bacterin serotype I (ERB). Control rainbow trout were immunized with the same antigens and held concurrently both at the Lamar and Leetown laboratories. The immune response in the fish was monitored by

demonstrating splenic and anterior hemolyptic plaque assay and humoral antibody titers by passive hemagglutination and bacterial agglutination.

Results of the samples taken 14 days after immunization (Table 1) are summarized. Two of the control trout immunized with the Yersinia ruckeri O-antigen had high numbers of antibody-producing cells from the spleen; all three had humoral antibody to the Y. ruckeri O-antigen particles. One of the control trout immunized with the Y. ruckeri ERB had a few detectable antibody-producing cells; all three samples had humoral antibody.

The results of the passive hemolyptic plaque assay of the shad were inconclusive; few antibody-producing cells were demonstrated in samples of each of the immunized groups. However, humoral antibody titers were demonstrated in the shad immunized with the Y. ruckeri O-antigen; low titers were detected in each of the ten samples of fish immunized with the DNP-KLH or the Y. ruckeri ERB.

Problems arose with the passive hemolyptic plaque assay of the shad because of the small spleen size in comparison with rainbow trout and the difficulty in obtaining adequate amounts of normal sera for the analysis of the antibody-producing cells.

The immune response of the shad will be followed in the remaining fish of each test group. Sera samples will be taken every two weeks from five fish of each group. Additional fish are being held so that the immunization tests can be repeated in a few months on larger fish.

In another labeling study, a rare earth element is being evaluated for marking juvenile American shad. The rare earth element, samarium, was incorporated into a formulated test diet (Abernathy Salmon Diet) for American shad at a concentration of 30 mg of samarium chloride hexahydrate per gram of diet.

Two different groups of shad, averaging 25 mm and 57 mm respectively, were fed the special samarium diet in excess for 30 days in an attempt to deposit the element in the tissue of the fish. Control (no samarium in diet) and test samples were collected on Day 7 and Day 30 of the test. Additional samples will be collected every 30 days during the next several months from treated fish that are being maintained to verify retention of the rare earth element.

Tissue samples are being processed and will be sent to a University of Michigan laboratory for neutron activation analysis. Quantity and quality of the samarium will be determined as to its value as a label for shad.

TRANSPORTATION METHODS FOR SHAD FINGERLINGS

During the past five years, the Lamar FCDC developed and refined techniques and equipment to increase the survival rate of juvenile shad transferred from one rearing unit to another or transported a distance via vehicle.

The transfer unit, designed and constructed by Lamar personnel in 1979 was only used to a limited extent this year. Instead, 12 or 19-L white plastic pails were used to transfer fish from one rearing unit to another or to a distribution truck because of the large numbers of fish that were handled this year. The pails were used instead of the shad transfer unit so that fish could be moved more quickly and could be enumerated more accurately. As we have noted in the past, the fish were apparently stressed more as they were crowded and captured in buckets as compared to handling them in the transfer tank. We did not, however, experience unacceptable mortalities by water-brailing the fish.

Approximately 325,000 juvenile shad, ranging in size from 20-26 mm, were successfully transported to the West Branch of the Susquehanna River and

stocked. Two distribution trips were made -- 215,000 fish (total of 4.3 kg) and 110,000 fish (2.2 kg).

Fish were crowded in rearing tanks and bucketed into a 1700-L trout transport tank that had been filled with water from a shad rearing tank (20°C) so that no water tempering was necessary. Common table salt (1.0%) was added to the tank to keep fish stress to a minimum.

Tank agitators were used to aerate the water and were responsible for the 5500 mortalities (2.6%) encountered during the initial distribution trip. The juvenile shad were sucked into the mechanical agitators and against the screen covering the agitators. The agitators were not used during the second trip and resulted in 99.5% shad survival at release.

Thirty-six adult shad, averaging 2-3 pounds and 61.5 cm in length, were transported in the same 1700-L rectangular tank during another experimental trial conducted in May. The fish were loaded onto the truck at the Conowingo Dam Fish Trap Facility near Conowingo, MD and transported approximately 80 miles (2 hr) to Fort Hunter Park Access, Harrisburg, PA. Four mechanical agitators and oxygen were used to aerate the tank water and a 1% saline solution was used to reduce fish stress during transport. Each fish was individually netted out of the tank and released into the Susquehanna River. Only one fish (2.8%) appeared in poor condition upon release into the river and was recaptured and discarded.

POND CULTURE OF AMERICAN SHAD FINGERLINGS

The Susquehanna River Anadromous Fish Restoration Committee had requested that the Lamar FCDC and Pennsylvania Fish Commission determine if pond culture could be used in conjunction with the intensive culture of juvenile shad to produce a more advanced fingerling for Susquehanna River stocking.

A 0.3-hectare macadam pond was filled with spring water in May and fertilized with 2 bales of alfalfa hay and 54.5 kg of dehydrated sheep manure, approximately two months before stocking. The pond was refertilized every two weeks (2 bales alfalfa hay and 36.4 kg sheep manure). Approximately 50,000-75,000 two-week-old shad fry (12-18 mm) were stocked in the pond in mid-July after a zooplankton bloom was well established. The fish were also fed Abernathy Salmon Diet (starter and 2/64) four times a day by walking around the perimeter of the pond and dispensing the feed by hand. Water temperature ranged between 20°-25°C during the culture period.

The pond was drained in September when the shad fingerlings were 11 weeks old. The pond was slowly drained for three days until all the fish were confined to the pond kettle area (4.0 m x 1.8 m x 0.5 m = 3.6m^3). Visibility was poor but the fish did not appear to be stressed. Approximately 27 kg of salt (0.8%) was added to the kettle to keep fish stress to a minimum. The fish were crowded in the kettle with screens, bucketed into tubs, and transferred via pickup truck to holding tanks (20°C) in the hatch house. Over 3000 fingerlings ($\bar{X}$ length = 64 mm) were successfully transferred. The remaining fish (approximately 1000) in the kettle began showing signs of stress (fish on their sides on the water surface) after being confined in the dirty water in the kettle for approximately one hour. Fresh, cold water (15°C) was pumped into the kettle 10-15 minutes after the fish appeared to be stressed. Within that short period of time many of the fingerlings jumped out of the water. All fish were dead within minutes.

The stress and mortality encountered by the fish probably could have been prevented if the fresh water had been introduced into the kettle at the start of the operation. This will be done in future pond-draining operations.

Shad survival from stocking (2 wk old) to harvest (11 wk old) appears to be extremely low (5.3 - 8.0%). This may be due to erroneous estimations of fry stocked. Every fifth bucket of fish was actually counted and the other buckets were estimated to enumerate the number of fish that were stocked. No other explanation is apparent at this time.

CULTURE METHODS FOR REARING AMERICAN SHAD FINGERLINGS

Approximately 1,641,000 viable American shad eggs (over 4.4 million total eggs) were supplied by National Environmental Services, Inc. and the Pennsylvania Fish Commission for FY-82 Development Center activities (Table 2). Eggs were collected on the Pamunkey and James Rivers in Virginia and the Columbia River in Oregon.

Lamar FCDC personnel collected another 147,600 viable eggs (310,500 total eggs) on the Delaware River (Pennsylvania). Eggs were shipped, enumerated, incubated, and hatched as in past years.

Note: Poor egg viability for most of the Columbia River egg shipments was due to poor fertilization of eggs because of a shortage of adult males; sperm from one male was used to fertilize eggs from a large number of females. The problem was corrected by fishing with finer mesh nets, which made it possible to capture a higher ratio of males.

Over 400,000 juvenile shad (approximately 25% survival), averaging 20 mm in length and 46 days of age, were intensively cultured this year by the Lamar FCDC indicating that standard salmonid rearing facilities could be used to cultivate juvenile shad on a production scale.

Shad fry (4 days old) were fed a diet of brine shrip (Artemia) and hydrated yeast cells during the initial five weeks of culture. All brine shrimp cysts

were decapsulated before being hatched and fed to the fish. Brine shrimp feeding was continued through the seventh week post-hatch at which time we stocked most of the shad. Fish that were held back at the hatchery for experimental purposes were either gradually converted to formulated food (Abernathy starter) or stocked in a pond where they fed on natural zooplankton in addition to formulated food that was hand fed to the fish four times a day.

Daphnia were not fed to the shad fry this year because of an inadequate supply of the cladocerans. An obvious reduction in fry growth as compared to past years was observed during the fifth week post-hatch and continued throughout the extensive brine shrimp feeding period; 80-day-old shad were 33% smaller in size in FY-82. Metamorphosis of the juvenile shad occurred four weeks later (10th -11th week) than it usually does under intensive culture conditions due to the reduction in fry growth. Survival of the juvenile shad did not appear to be affected by the absence of daphnia from the diet fed to the fish.

As in past years, shad mortality rates were high during the initial three weeks post-hatch; highest mortality usually occurs around days 11-15 post-hatch when most fry die that did not begin feeding for one reason or another. Mortality rates continued throughout the intensive culture period but declined and leveled off with time (0-2% mortality per day). It was difficult this year to obtain an accurate enumeration of fry mortalities due to a manpower shortage.

Rearing density test results indicate that shad fry can be reared at a density as high as 100 fry/liter with no significant difference in mortality rate during the initial five weeks post-hatch. As expected, there is a

reduction in growth of fish reared at 100 fry/liter (200 mg/l) versus fish reared at a density of 50 fry/liter (100 mg/l) during this five-week period. Test results last year indicated that a density of 30 fish/liter (1200 mg/l), resulted in greater growth and survivability than density of 50 fish/liter (2000 mg/l) during the fifth to the tenth week post-hatch.

Therefore, it appears that fry can be successfully reared for five weeks at densities as high as 100 fry/liter if size of the stocked fry is not a critical factor. However, if the goal of a culture effort is to produce as large a juvenile shad as possible in 18, 20, 35...days, larger fish could be produced by rearing the fish at lower, but yet economic and practical, densities.

Shad reared in circular tanks grew faster than fish reared in rectangular tanks; this was also evident in FY-81 and is apparently due to the food being suspended in the water column for a longer period of time and also being more evenly distributed throughout the entire rearing tank. Although the fish in both the circular and rectangular tanks are fed at the same rate, the food is more accessible to the fish reared in the circular units.

Two lots (865 and 2050 fish) of larger shad (73-79 mm) were held in hatch house holding tanks at 17°C $\pm$ 2 for approximately one and a half months with minimal mortality (5.5% and 6.2% respectively). The fish were actively feeding on formulated diet and appeared to be very healthy.

The two lots were lost during separate five-day periods. The fish in each tank initially acted more skittish and became darker in color. Higher than usual mortalities occurred two to three days later and all fish were dead five days after the abnormal behavior was first observed. Most mortalities resulted from the shad darting into the walls of the rearing unit and literally leaping

out of the tank.

Both groups of fish were similar in size, averaging 83.0 and 82.8 mm in length, and in age, 122-days-old and 130-days-old respectively. Water quality was normal: N_2 = 101%, O_2 = 9.0 mg/l, NH_3 = 0.3 mg/l, pH = 7.6, and water temperature = 18°C.

The unusual mortality may have been related to shad smoltification. Two more lots of smaller shad are currently being held in rearing units at Lamar to observe if a similar situation occurs when the fish average 80-85 mm in length.

Table 5.1 Results of Shad and Rainbow Trout Samples Taken 14 Days After Immunization

Sample	Genus	Antigen	Labeled Sheep Red Blood Cells	Control Sheep Red Blood Cells	Antibody	# Lymphocytes
1	Salmo	Y. ruckeri 0 (100mg/fish)	4+	---	4+	96
2	Salmo	Y. ruckeri	2+	---	4+	200
3	Salmo	Y. ruckeri	3+	---	1+	198
4	Salmo	Y. ruckeri ERB (0.5 ml/fish)	2+	---	1+	120
5	Salmo	Y. ruckeri ERB	2+	---	1+	90
6	Salmo	Y. ruckeri ERB	2+	---	2+	73
7	Alosa	Y. ruckeri 0 (100mg/fish)	--	---	2+	64
8	Alosa	Y. ruckeri	1+	---	2+	69
9	Alosa	Y. ruckeri	--	---	--	76
10	Alosa	Y. ruckeri	1+	---	±	98
11	Alosa	Y. ruckeri	1+	---	1+	60
12	Alosa	DNP-KLH (25 mg/fish)	1+	---	--	--
13	Alosa	DNP-KLH	-*	---*	--	80
14	Alosa	DNP-KLH	-*	---*	2+	62
15	Alosa	DNP-KLH	-	---	1+	79
16	Alosa	DNP-KLH	-	---	--	60
17	Alosa	Y. ruckeri ERB (0.1 ppm bath)	-	---	1+	60
18	Alosa	Y. ruckeri ERB	-	---	--	--
19	Alosa	Y. ruckeri ERB	-	---	±	--
20	Alosa	Y. ruckeri ERB	1+	---	±	--
21	Alosa	Y. ruckeri ERB	--	---	±	--

A system of 1+ through 4+ was used to designate various levels of positive results.

*Non-specific plaques and bubbles in agar.

TABLE 5.2 1982 American Shad Egg Collection and Viability, Lamar FCDC

DATE	RIVER	COLLECTOR	LITERS	TOTAL EGGS	VIABLE EGGS	% VIABLE EGGS
4/21	Pamunkey	NES+PFC	2.80	154,650	1% viability on 4/27	
4/29	James	NES+PFC	6.00	228,030	83,946	36.8
5/28	Delaware	USFWS	7.50	310,448	147,653	47.6
6/15	Columbia	NES	8.15	298,661	93,543	31.3
6/16	Columbia	NES	14.50	493,474	133,930	27.1
6/17	Columbia	NES	12.50	553,461	197,855	35.7
6/18	Columbia	NES	13.65	797,185	269,852	33.9
6/19	Columbia	NES	9.20	409,829	212,636	51.9
6/22	Columbia	NES	10.00	328,840	141,975	43.2
6/23	Columbia	NES	9.30	288,345	166,677	57.8
6/24	Columbia	NES	23.40	867,651	340,728	39.3
	TOTAL		117.50	4,730,574	1,788,795	40.5 avg.

JOB VI. SUMMARY OF OPERATION OF THE CONOWINGO DAM FISH LIFT IN SPRING 1982

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INTRODUCTION

The Conowingo Dam Fish Passage Facility (hereafter Fish Lift) has been operated since 1972 as part of a cooperative private, state, and federal effort to restore American shad to the upper Susquehanna River. Early goals of lift operation were to determine if American shad could be attracted and collected from below the Conowingo Dam and transported upriver. Subsequently the goal has been to monitor fish populations below Conowingo Dam and transport as many American shad and herrings as possible to aid their restoration. Operation of the fish lift is one of many long term commitments by Philadelphia Electric and Susquehanna Electric companies to aid in the restoration of migratory fishes to the Susquehanna River.

Objectives of the 1982 operation were to monitor (1) relative abundance of Alosa species in the Conowingo Dam tailrace, (2) species composition of fish in Conowingo Dam tailrace (3) obtain life history information from selected anadromous fish species and resident species, (4) contribute to restoration by trap and transfer of prespawned American shad and river herring upstream, and (5) assist Maryland Tidewater Administration in their shad population assessment by capture of tagged individuals.

Methods

Lift operation was delayed until 15 April due to unseasonal snow storms and high river flows. Weir gate and crowder motors were first installed on 30 March. It was anticipated that the fish lift would be operational on 3 April. However, mechanical problems with the crowder were encountered. On 4 April river flows increased and all motors were removed.

Prior to the operation of the lift, starting 22 March daily conversations with personnel at Owen's Fish House (Perryville, Maryland) were made to determine if commercial fishermen were catching anadromous fishes in the river or Susquehanna Flats. Few fished due to Maryland's closure of the shad fishery and limited numbers of river herring were available at the time. Starting 1 April daily field trips were taken to Deer and Octararo creeks to determine if the traditional dip net fishery for river herring had started. It appeared that the dip net fishery has fallen off from past years. The first dip netter was observed on 20 April at Deer Creek. A visual survey of both creeks was conducted daily from 1 April to 26 April and intermittently up to 26 May to determine if river herring were present in the lower river. A limited number of herring were first observed on 2 April in Deer Creek at Stratford Bridge. However, no

herrings were observed again until 4 May when several hundred were observed. From the observations between 4 May and 26 May at temperatures ranging from 61.0F to 74.0F several thousand herring and a limited number of lampreys were observed spawning in both creeks.

The fish lift (Figure 1) was operated initially for two days (15 and 16 April) in an effort to determine if alosids were present in the tailrace. Beginning on 19 April operation as outlined in the Susquehanna River Anadromous Fish Restoration Committee's 1982 work plan began and continued to 29 April. Starting 1 May with the cooperation of Philadelphia Electric and Susquehanna Electric companies operation was modified to determine if the catch of the American shad or the relative efficiency of the lift could be increased under various tailrace conditions. From 1 May to 1 June the lift operated daily with the exception of 15 May when no operation occurred due to a mechanical failure of the hopper travel system. From 1 to 6 May daily operation began one hour before sunrise and continued to noon. Additional operation occurred whenever one or more shad was taken between 1100-1200 hrs as conditions permitted.

Lift operations were further modified to include the off peak hours of generation during each afternoon until dusk of

each day or to such time as conditions permitted. Starting 7 May daily operation started at 0600 hrs and continued as outlined above until 1 June whenever possible. The lift was operated every third day between 2 and 15 June with the same time limitations as the preceeding period.

The mechanical aspect of fish lift operation was similar to that described in the Operation and Maintenance Manual (Anon, 1972). Fishing time (i.e., time crowder gates were open) ranged from 1 to 60 minutes and depended upon abundance of fishes, large numbers of fish the shorter the time. Fishing time of 30 minutes was most frequently used. An intermediate crowder gate position (1 ft. opening) was used. The crowder doors were usually closed from 3 to 5 minutes between fishing periods, depending upon abundance of fishes and the time required to process the catch.

Based on an agreement with the State of Maryland, Susquehanna Electric Company, has continually released a minimum of 5,000 cfs from Conowingo Dam from approximately 15 April to 15 June from 1972 to 1982. When the fish lift operated in prior years, minimum flow was generally discharged via Unit No. 1 and/or 2 which are adjacent to the lift. This was done in an effort to attract fish to the west side of the tailrace and improve the performance of the trap. In 1982 this procedure was changed during the trap

season. Starting on the morning of 24 April and continuing to 5 May, 5,000 cfs was released via Unit No. 2. From 5 May to 15 June continuous flow of 5,000 cfs was discharged via either Unit No. 5 or Unit No. 6 whenever possible to reduce the competition between the attraction flow from the fish lift and the higher discharge from the adjacent Unit No. 1 and/or 2.

Attraction velocity and flow in 1982 were generally similar to those maintained in the later part of the 1981 lift season. This was accomplished by duplicating the same house unit, weir gate and valve settings (Table 1). These settings resulted in the following: approximately a 1-ft differential in the holding channel and tailrace elevation, a velocity of 1-ft/sec in the holding and trapping area and an average attraction velocity of 6-ft/sec over each weir gate. Prior to 1 May attraction velocity and holding channel velocity was maintained at 6 ft/sec and 1-ft/sec, respectively. However, hydrologic configuration in the area of the lift between the crowder gate and weir gate entrances was different from that during the period after 30 April. By adjusting valves 1, 2, and 3 hydrologic conditions in this area of the trap were improved creating a more uniform flow from the holding and trapping area to the weir gates. This appeared to decrease the large concentration of fishes,

particularly gizzard shad and carp in the area between the crowder gates and weir gates. These concentrations of fish had been observed decreasing and/or delaying the numbers of fish collected in the trapping area.

A chemical attractant, phenethyl alcohol, was scheduled for release from the fish lift during a 24-hour period every other scheduled day of operation from start-up until water temperature reached 68F as outlined in SRAFRC's 1982 work plan. However, the attractant was changed to morpholine. Release of morpholine started on 19 April. However, due to equipment malfunction it was not released again until 3 May and was released on and alternate day scheduled basis up to and including 14 May, at which time releases were terminated due to water temperature criteria being satisfied. This chemical was used by the Pennsylvania Fish Commission to imprint larval American shad reared at the Van Dyke Hatchery (Thompsontown, PA) and stocked in a tributary (Juniata River) of the Susquehanna River. It was hoped that adults resulting from these introductions would be attracted to the fish lift by morpholine release. Due to limited and sporadic release of the attractant it is impossible to determine what affect it may have had on the catch of shad in 1982.

Fishes were processed as described by McGhan (1977) and sorted in a 6 x 12 x 4 F tank supplied with running river water. Initially, fishes were counted or subsampled and released back to the tailrace. When the number of fish increased along with the catch of American shad the number of fish of each species was estimated and released. This eliminated any unnecessary handling or overcrowding mortalities. Length, weight, sex and scale samples were taken from blueback herring, alewife, striped bass, and striped bass x white bass hybrid. Common names of fishes (Bailey et al. 1970) are used throughout the text and tables. A list of common and scientific names is given in Table 2.

Initially, American shad were dip netted from the sorting tank into one of 3 circular tanks that were continually supplied with river water. Healthy, active fish were tagged with Floy anchor tags. All shad were observed prior to release to determine their condition, and healthy individuals were released via a water filled pipe back to the tailrace. Length, weight, sex and spawning condition were determined as conditions permitted. Scale samples were taken when possible. Procedures for handling and disposition of American shad were modified when it became evident that the lift was capable of trapping large numbers

of American shad in a prespawned condition that could be transported upstream.

Philadelphia Electric Company initiated a transportation program for these shad. PECO's 800 gallon circular transfer unit that was used by RMC in 1980 to transport American shad from the Holyoke Fish Lift to the Susquehanna River was equipped to transport the shad.

Test procedure for the system was as follows: (1) system was filled with river water, (2) pumps were filled with gas and started, (3) determined the system was creating a desired flow, (4) determined by titration that oxygen was being added into the system, (5) seventy-five prespawned American shad were loaded, (6) dissolved oxygen was measured and fish observed every half hour over a period of three hours, (7) shad were trucked to Lapidum, MD and released, and finally (8) determined if mortalities had occurred both during the test and transportation upon their immediate release. Following successful completion of this test the system was considered suitable for transportation of prespawned shad to spawning areas above York Haven Dam. During the three day period in which the transport system was being assembled and tested the U. S. Fish and Wildlife Service made available a conventional trout stocking vehicle.

Transportation of shad followed the same basic procedures as used during the test of the system. After shad were released to the river all dead shad were collected from the river and processed for life history information.

With the transportation system available and sufficient numbers of herring being trapped to warrant transportation, herrings were trucked to Conowingo Pond.

Data on river flow and water temperature (F) are summarized in Figure 2. Daily river flows ranged from 15,400 to 92,700 cfs. Flows fluctuated among days but generally decreased from April through the end of May and increased to a high of 92,700 cfs on 8 June and thereafter generally decreased. Water temperature ranged from 48.7 to 73.4F and generally increased as flows decreased. However, as flows increased late in the season water temperatures decreased.

RESULTS AND DISCUSSION

Catch Composition

In 44 days of fish lift operation 1,403,174 fish representing 12 families and 47 species were caught in 725 lifts with a total fishing time of 336 hours (Table 3, Figure 3). Species in order of abundance were gizzard shad, white perch, channel catfish, blueback herring and carp.

The catch in 1982 was the second largest in a single season at the lift (Table 3). The lift was not operated every hour from start up to shutdown on everyday. Catch composition and generation played an important role in determining at what time the fish lift was operated. Generally, total catch of fish in 1982 was similar in total number to catches in previous years where similar amounts of effort were expended. However, composition of the catch was considerably different. The catch of alosid, particularly the American shad was substantially increased.

With catches of American shad increasing the operation of the first lift was changed daily. The effort changed as needed to effectively collect American shad and other alosids. This was accomplished by operating the lift around the normal operations of the power station. Effort was increased so that restoration of American shad could be aided by a trap and transfer program of prespawned adults to upriver spawning areas.

Experimental Flows

The effects of varying flows from the Conowingo Dam, including experimental shutdowns of short durations (<2hr), were evaluated on the relative efficiency of the fish lift on four dates. Examination of data collected during a longer (4 hr) shutdown requested by a resource agency on 27

April 1980 revealed that 76% of the total catch for the day was made during the 4hr shutdown with only 16% of the total effort. All 22 American shad trapped that day were collected during the complete shutdown.

The flow conditions tested were:

1) Continuous generation of one or more units followed by a shutdown of short duration

2) discharge of four or more generating units followed by a shutdown of short duration

3) Transition period between flow changes (e.g. increases or decreases in flows after either of the above conditions)

Although the species composition was generally similar among the experimental flow conditions, the relative abundance of fishes varied between dates, time of capture, time and magnitude of run, and generation status of the unit(s) adjacent to the fish lift. The catch of selected fishes was generally much higher during a shutdown or when a single unit, particularly unit 5, was discharging (5,000 cfs) than at higher flows (Tables 4-6). The total catch was composed primarily of white perch, gizzard shad, and channel

catfish. However, the catch of the American shad at these flows was of particular importance with respect to relative efficiency of the fish lift.

The catch of the American shad was greater at lower flows than at higher flows (Tables 4-6). Rarely more than 5 shad per lift were collected when four or more units were discharging. In contrast, 16 (80%) of the 20 lifts taken on 9 May 1982 yielded more than 5 shad per lift. Most shad were collected either before 1100 hours in the morning or after 1500 hours in the afternoon. The highest daily catch of shad of the season occurred on 9 May 1982, a weekend day with a relatively low level of generation.

In addition, the effects of lower flows on the increased relative efficiency of the lift were evident on 18 May 1982. The catch of the American shad averaged 46 per hour when only Unit 5 was operating while no shad were collected at higher flows (Table 7). Coincident to this unprecedented catch of the American shad was a relatively lower catch of the nuisance species, gizzard shad. The catch of all the other migratory fishes was several fold higher at lower flows than at higher flows. In fact, migratory fishes were not collected at higher flows on that day. The large catch of the gizzard shad appeared to be due to the operation of Unit 1.

These data provide a strong indication to develop an efficient and economical plan for the operation of the fish passsage facility to minimize interference to the efficient operation of the dam and increase the collection of American shad. However, some fine tuning in operational modifications may still be dictated by the local conditions. A rigorous statistical analysis of the existing data coupled with further experimentation may be needed to separate the important sources of variation in catch of the American shad. The analyses may include separating the effects of unit number generating, amount and duration of generation, and competition for attraction flow with the adjacent units.

Alosid Catch

The total catch of 2,039 American shad (Figure 4) in 1982 was greater than the combined catch of shad from 1972 to 1981. This unprecidented catch of shad occurred at a time when the Susquehanna population levels were at or near a record low. Several factors maybe responsible for the increased catch: 1) increased relative efficiency of fish lift; 2) closure of American shad fishery in the State of Maryland; and 3) increased availability and an increase in population levels of American shad.

In 1972 to 1981 various modes of operation were employed at the lift with limited success in trapping shad. Apparently, because of the generally low catch of the shad in the lift no rigorous attempt was made to identify conditions that might enhance the relative efficiency of the lift. However, our examination of those data showed that the catch was highest in the morning during periods of low flows from the dam. Since the shad were generally captured in late May and June when water temperatures were greater than 6º F which coincided with generally reduced flows this lead to the belief that the lift was not capable of collecting American shad that where available in the tailrace. The 1982 experience indicates the facility may not have collected larger numbers of shad in preceeding years due to competing flows from the adjacent units or higher flows and/or an absence of a large population of shad of upstream origin with the desire to continue movement upriver. In those years either Unit No. 1 and/or 2 was generally used to provide continuous flows in the spring. These flows from the adjacent units offered competition to the attraction flows from the fish lift thereby reducing the relative efficiency of the lift. Most shad collected in preceeding years may have been of tidal origin and had no real desire to continue upriver.

Over 99% of the American shad collected in 1982 were captured after 30 April. Although the catch of shad varied from lift, day, time of day, and according to dam generation it was greatest when station generation was one unit or less. Partitioning the absolute (total) catch of shad by station generation, weekdays, weekend days showed that 71% of the shad were collected on weekends or when one unit was operating. About 60% of the total catch occurred when one or no unit was generating. Of the 918 shad collected on weekend days 680 (76%) were collected when one or no unit (5,000 cfs) was in operation. However, when the data were standardized to catch per effort (Table 8), shad catch was over four times greater at lower flows (one unit or less) than at higher flows (two or more units generating). It is interesting to note that only 25% effort spent at lower flows accounted for 80% of the shad catch. Only 20% of the shad (based on catch per hour) were captured when two or more units were generating. These data are similar to those gathered in April 1980 when more shad were collected at lower flows than higher flows. Catches were generally greater during the morning and evening hours. Figures 5 through 7 are indicative of this trend.

The American shad were collected at water temperatures from 59F to 73.4F (Table 9). The largest percentage of shad

(85%) were collected at temperatures >62F. The catch of the American shad increased as the river flows were decreasing and water temperatures were increasing. It should be noted that the water temperatures given here are those which were taken at the time when fish were caught. More extensive daily and hourly temperature and river flow data taken in other study programs may be utilized in future analyses of the data to further delineate the role of these variables with respect to catch of shad.

A total of 543 American shad was floy tagged at the fish lift in 1982 and released back to the tailrace. Tagging started on 27 April and continued to 22 May as time and conditions permitted (Table 10). Some 44 were recaptured; two fish were recaptured twice. One recapture was tagged in 1981 and remained free for a year. Six shad caught and tagged by Maryland Tidewater fisheries personnel in 1982 were captured in the lift.

The average free days for all recaptures from the tagging program in 1982 was 12. The shortest free period was 4 days (Table 10). This was exhibited by two fish one of which was tagged on 2 May and the other on 22 May. The longest period of time a shad was free was 25 days. That fish was tagged on 6 May and recaptured on 31 May.

Anglers and commercial fishermen captured a total of 36 shad (7% of the total marked) that were tagged at the trap. It appears that even with a closed season for American shad within the State of Maryland there is a fair percentage of shad that are collected indirectly while fishing for other species.

One fish captured by a commercial gill netter was collected at 43° latitude and 70° longitude on 30 November in the Altantic Ocean off Portland, Maine. Although one recapture provides limited information it indicates that exploitation of Susquehanna shad occurs outside of Maryland (area closed to fishing) by other fisheries.

Catch of other alosids increased in 1982 from a low in 1980 (Table 3). The total number of blueback herring, alewife and hickory shad collected was 25,249, 3,433 and 15, respectively. Catches of river herring occurred over short periods of time. Over 86% of the alewives collected were trapped in two days (25 April and 12 May) when water temperatures were 57F and 65F, respectively. The major portion (68%) of blueback herring was collected in morning operations starting on 11 May and continuing to 13 May at water temperatures of 65F and 66F. As in the case of the American shad, the catch of river herrings was severally higher at lower flows than at higher flows (Table 4-7).

Adult Transportation

Transportation of pre-spawned American shad occurred from 5 to 21 May. This was the first season since the fish lift became operational in 1972 that substantial numbers of shad were available for transport upstream of York Haven Dam. Some 917 adults were transported to three release sites(Table 11). Release sites used were the public boat launch at Lapidum, MD and the access sites at Fort Hunter and City Island, PA. At the recommendation of the Pennsylvania Fish Commission the primary release site used was the City Island access area in Harrisburg, PA. The water depth at the site was 5 to 8 ft; the site was easily accessible and was the closest public access suitable above York Haven Dam.

Transportation began on 5 May when 36 shad were transported to the Fort Hunter release site by USFWS personnel from the Lamar Research and Development Center in a conventional trout stocking truck. These fish were collected at a water temperature of 61F. Fish were held in circular holding tanks prior to being transported in the rectangular tank. Survival for the trip was 97% which was much higher than anticipated.

On 8 May 1982 the circular transport system was tested at the facility using 75 shad over a three hour period.

Fish were then taken downstream of the facility and released at the Lapidum boat launch. All shad survived indicating the system was functioning properly and ready to use for transportation of American shad to spawning areas above York Haven Dam. For the period 9 May-21 May a total of 806 shad was transported to the release site at City Island with an overall survival of 95% (Table 11). During this period 68% of all shad collected at the facility were transported in 13 trips. Individual trips averaged 2 hrs from Conowingo Dam to release point of fish. Load size varied from 36 to 85 fish on each trip. Trip survival varied from 78% to 100%. Fish were transportated at water temperatures that varied from 61F to 72.5F.

Trucking of American shad from the fish lift to upstream areas was considered successful and a viable method for bypassing the hydroelectric dams. Although ultimate capacity of this trucking program is unknown, experience from 1982 indicates that a large number of American shad can be trucked successfully.

On 13 May, 730 pre-spawned herring were transported in two trips to the public access site at Broad Creek, MD (Table 12). The first trip contained 280 fish and the second contained 450 fish during which survival was 100%. One of the reasons for transporting herring was to test load

capacity for the system. However, total load capacities were not reached due to unavailability of sufficient numbers of herring after 13 May. It is anticipated that up to 1,000 herrings per trip may be transported in this system effectively.

Conclusions

The 1982 operational season indicated that the fish lift is capable of collecting large numbers of American shad and relative efficiency of the lift was four times greater at lower flows than when two or more units were operating. The American shad did not experience delay in reaching the base of Conowingo Dam and entering the lift. The collection and transportation of increased numbers of prespawned adult shad from the lift contributed to the restoration program. Operation of the fish passage facility should remain flexible so that increased trapping, handling, and transfer of fishes can continue. Data collected in 1982 provides strong indication that the lift can be efficiently operated in conjunction with an economical operation of the dam and aid the restoration of migratory fishes to the upper Susquehanna drainage.

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TABLE 1. Service units flow used to obtain attraction and holding channel velocities at the Conowingo Fish Lift, 1May-15 June 1982.

Condition	Service Unit Gate Setting No. 1	No. 2	Flows (cfs)	Entrance Weir Depth Below Tailrace	Attraction Velocity (ft/sec)	Holding Channel (ft/sec)
High Flow	35%	75%	265	6.9	6.0	1.0
Low Flow	35%	35%	150	5.1	6.0	1.0
Low Low Flow	35%	0%	75	3.1	6.0	1.0

TABLE 2. List of scientific and common names of fishes collected at the Conowingo Fish Lift, Spring 1972-1982 (according to Bailey, et al., 1970).

Scientific Name	Common Name
Family - Petromyzontidae	Lampreys
Petromyzon marinus	Sea lamprey
Family - Anguillidae	Freshwater eels
Anguilla rostrata	American eel
Family - Clupeidae	Herrings
Alosa aestivalis	Blueback herring
Alosa mediocris	Hickory shad
Alosa pseudoharengus	Alewife
Alosa sapidissima	American shad
Brevoortia tyrannus	Atlantic menhaden
Dorosoma cepedianum	Gizzard shad
Family - Salmonidae	Trouts
Salmo gairdneri	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
S. Fontinalis x *S. namaycush*	Splake
Family - Coregonidae	White Fishes
Coregonus artedii	Lake herring
Family - Esocidae	Pikes
Esox niger	Chain pickerel
Esox lucius	Northern pike
Esox masquinongy	Muskellunge
E. masquinongy x *E. lucius*	Tiger muskie
Family - Cyprinidae	Minnows and carps
Carassius auratus	Goldfish
Cyprinius carpio	Carp
Nocomis micropogon	River chub
Notemigonus crysoleucas	Golden shiner

TABLE 2. Continued.

Scientific Name	Common Name
Family - Cyprinidae (continued)	
Notropis sp.	Shiners
Notropis amoenus	Comely shiner
Nortopis hudsonius	Spottail shiner
Notropis procne	Swallowtail shiner
Notropis rubellus	Rosyface shiner
Notropis spilopterus	Spotfin shiner
Pimephales notatus	Bluntnose minnow
Rhinichthys atratulus	Blacknose dace
Rhinichthys cataracta	Longnose dace
Family - Catostomidae	Suckers
Carpiodes cyprinus	Quillback
Catostomus commersoni	White sucker
Erimuzon oblongus	Creek chubsucker
Hypentelium nigricans	Northern hogsucker
Moxostoma macrolepidotum	Shorthead redhorse
Family - Ictaluridae	Freshwater catfishes
Ictalurus catus	White catfish
Ictalurus natalis	Yellow bullhead
Ictalurus nebulosus	Brown bullhead
Ictalurus punctatus	Channel catfish
Noturus sp.	Madtoms
Noturus insignus	Marginal madtom
Family - Belonidae	Needlefishes
Strongylura marina	Atlantic needlefish
Family - Cyprinodontidae	Killifishes
Fundulus heteroclitus	Mummichog
Family - Percichthyidae	Temperate basses
Morone americana	White perch
Morone saxatilis	Striped bass
M. saxatilis x	Striped bass x
M. chrysops	White bass

TABLE 2. Continued.

Scientific Name	Common Name
Family - Centrarchidae	Sunfishes
Ambloplites rupestris	Rock bass
Lepomis auritus	Redbreast sunfish
Lepomis cyanellus	Green sunfish
Lepomis gibbosus	Pumpkinseed
Lepomis macrochirus	Bluegill
Micropterus dolomieui	Smallmouth bass
Micropterus salmoides	Largemouth bass
Pomoxis annularis	White crappie
Pomoxis nigromaculatuss	Black crappie
Family - Percidae	Perches
Etheostoma olmstedi	Tessellated darter
Etheostoma zonale	Banded darter
Perca flavescens	Yellow perch
Stizostedion vitreum	Walleye
Percina caprodes	Log perch
Percina peltata	Shield darter

TABLE 3. Comparison of annual catch and effort expended in spring at the Conowingo Fish Lift, 1972-1982.

YEAR	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
NO. DAYS	52	62	58	55	63	61	35	29	30	37	44
LIFTS	804	1527	819	514	684	707	358	301	403	490	725
OPER. TIME(HR.)	598	981	500	307	375	413	212	187	222	275	502
FISHING TIME(HR)	305	623	222	189	252	245	136	123	117	178	336
# SPECIES	40	43	42	41	38	40	44	37	42	48	47
AMERICAN EEL	805	2050	91937	64375	60409	14601	5878	1602	377	11329	3961
BLUEBACK HERRING	58198	330341	340084	69916	35519	24395	13098	2282	502	618	25249
HICKORY SHAD	429	739	219	20	4	1	-	-	3	1	15
ALEWIFE	10107	144727	16675	4311	235	188	5	9	9	129	3433
AMERICAN SHAD	182	65	121	87	82	165	54	50	139	328	2039
GIZZARD SHAD	24849	45668	119672	139222	382275	742056	55104	75553	275736	1156662	1226374
ATLANTIC MENHADEN	-	-	112	-	506	1596	-	-	16	42	-
TROUTS	1	-	-	-	-	-	-	-	-	-	-
RAINBOW TROUT	34	67	20	24	54	291	70	15	23	219	20
BROWN TROUT	172	286	483	219	427	700	261	324	258	207	219
BROOK TROUT	1	3	4	1	-	2	23	-	4	3	5
SPLAKE	-	-	-	-	-	-	-	-	-	2	-
CHAIN PICKEREL	-	1	10	-	-	1	-	-	-	1	-
NORTHERN PIKE	-	2	2	-	-	2	2	4	3	-	5
MUSKELLUNGE	19	104	9	7	12	48	14	5	27	1	4
MINNOWS	-	-	-	-	-	-	-	-	-	-	1
GOLDFISH	-	27	1	9	4	1	-	-	-	1	-
CARP	8370	16362	34383	15114	6755	16256	11842	14946	8879	18313	15362
RIVER CHUB	-	-	-	-	-	-	-	-	1	-	-
GOLDEN SHINER	165	430	437	751	1622	652	221	304	35	155	92
COMELY SHINER	5	252	3870	2079	740	769	1152	1707	761	281	18218
SPOTTAIL SHINER	34	137	2036	268	1743	8107	8506	1533	849	31	315
SWALLOWTAIL SHINER	-	-	-	-	-	-	-	-	-	3	-
ROSYFACE SHINER	1	-	-	1	-	-	-	-	-	-	8
SPOTFIN SHINER	103	80	3011	1231	45879	7960	3751	41	314	528	622
BLUNTNOSE MINNOW	-	-	-	-	-	-	4	-	-	-	-
BLACKNOSE DACE	-	-	-	-	-	-	-	-	-	-	2
LONGNOSE DACE	-	-	1	-	-	-	4	-	-	-	-
SHINERS	264	3	-	-	-	-	-	-	-	-	6
QUILLBACK	7117	27780	14565	8388	9882	6734	2361	5134	2929	3622	1617
WHITE SUCKER	321	1034	286	152	484	282	189	906	1185	1394	582
CREEK CHUBSUCKER	2	3	1	-	-	-	-	-	-	8	2
NORTHERN HOG SUCKER	-	2	-	1	5	-	3	6	13	1	-
SHORTHEAD REDHORSE	1097	8820	834	845	1276	1724	697	2163	1394	6533	6978
WHITE CATFISH	3070	6394	2200	6178	1451	3081	982	515	605	2199	565
YELLOW BULLHEAD	7	45	1	32	2	47	25	13	18	36	61
BROWN BULLHEAD	510	5328	1612	740	451	2416	125	284	675	531	338
CHANNEL CATFISH	61041	55084	75663	74042	41508	90442	48575	38251	38929	55528	80941
MARGINED MADTOM	-	-	-	-	-	-	-	-	-	-	6
MADTOMS	-	-	-	-	-	-	-	-	-	-	1
MUDDUCHOG	-	-	-	-	1	-	-	-	-	-	1
WHITE PERCH	50991	687893	897113	511699	568018	224843	113164	83103	26971	83363	53527
STRIPED BASS	3142	895	1150	174	13	1196	934	260	902	3277	60
ROCK BASS	66	32	31	46	227	128	50	46	88	381	138
REDBREAST SUNFISH	707	2056	1398	3040	3772	8377	8187	3466	1524	1007	1335
GREEN SUNFISH	3	-	4	39	81	168	25	-	16	28	91
PUMPKINSEED	229	2578	2579	1000	878	1687	512	323	446	306	848
BLUEGILL	567	1823	927	3058	2712	5442	1361	813	942	1299	1184
SMALLMOUTH BASS	181	298	119	154	327	701	262	374	455	881	1095
LARGEMOUTH BASS	82	89	23	19	33	14	5	22	41	13	20
WHITE CRAPPIE	4857	668	4371	9290	2987	1003	673	384	100	231	303
BLACK CRAPPIE	8	8	25	45	86	199	103	53	15	20	39
TESSELLATED DARTER	-	1	8	1	-	-	-	-	-	2	-
YELLOW PERCH	5955	1090	682	494	2904	735	526	379	373	1007	724
LOGPERCH	-	-	-	-	-	-	27	-	-	-	-
SHIELD DARTER	-	-	-	-	-	-	-	-	-	1	-
WALLEYE	1837	2738	1613	369	2267	2180	967	2891	4153	2645	504
BANDED DARTER	-	-	-	-	-	-	1	-	-	-	-
ATLANTIC NEEDLEFISH	1	-	-	1	-	-	-	-	-	2	-
SEA LAMPREY	-	2	-	2	29	11	1	3	1	55	56
LAKE HERRING	-	1	-	-	-	-	-	-	-	-	-
STRIPED BASS X WHITE BASS	-	-	-	-	-	-	270	273	2674	39	160
TIGER MUSKIE	-	-	-	-	-	-	13	132	34	53	56
	241130	1300345	1617888	917083	1175616	1169161	276045	197769	372379	1353308	1803174

TABLE 4. Comparison of catch/hr of selected fishes collected at various generation modes at the Conowingo Fish Lift, 1 May 1982.

Generation Status(units)	1	4	>4	Shutdown
Fishing Time(min)	105	150	158	60
Species				
American eel	-	-	-	-
Blueback herring	0.6	-	0.7	-
Alewife	5.7	0.4	0.4	4.0
American shad	2.3	14.8	-	1.0
Gizzard shad	12608.0	13600.0	4352.9	27750.0
White perch	116.6	6.4	20.5	11.0
Channel catfish	192.6	12.0	14.5	15.0

TABLE 5. Comparison of catch/hr of selected fishes collected at various generation modes at the Conowingo Fish Lift, 5 May 1982.

Generation Status(units)	1	>4	Shutdown
Fishing Time(min)	100	286	60
Species			
American eel	0.6	-	-
Blueback herring	-	0.2	3.0
Alewife	-	-	3.0
American shad	16.7	0.8	5.0
Gizzard shad	3922.2	12159.3	24500.0
White perch	59.9	1.0	1000.0
Channel catfish	1018.0	157.2	410.0

TABLE 6. Comparison of catch/hr of selected fishes collected at various generation modes at the Conowingo Fish Lift, 9 May 1982.

Generation Status(units)	1		Shutdown	Changing
Fishing Time(min)	230	285	60	15
Time of Day	AM	PM	AM	PM
Species				
American eel	0.3	0.4	-	-
Blueback herring	43.6	28.2	6.0	48.0
Alewife	5.7	-	-	-
American shad	36.8	17.5	36.0	56.0
Gizzard shad	3707.6	6842.1	9200.0	26000.0
White perch	117.5	311.6	200.0	320.0
Channel catfish	2.6	0.6	1.0	320.0

TABLE 7. Comparison of catch/hr of selected fishes collected during two generation modes at the Conowingo Fish Lift, 18 May 1982.

Generation Status(units)	1	1
Fishing Time(min)	60	30
Species		
American eel	35.0	-
Blueback herring	20.0	-
Alewife	-	-
American shad	46.0	-
Gizzard shad	3750.0	8000.0
White perch	75.0	60.0
Channel catfish	65.0	100.0

TABLE 8. Comparison of the American shad catch, catch per effort, and effort between low (one or less unit generation) and high discharges (two or more unit generation) at the Conowingo Fish Lift, 15 April-15 June 1982.

Generation Status	# Shad Caught	Total Minutes Fished	Number of Lifts	Shad Catch per/hr
One or less	1206	5191	212	1393.95
Two or more	833	14962	513	334.05
Total	2039	20153	725	

TABLE 9. Catch of American shad in the Conowingo Fish Lift by water temperatures, April-June 1982.

	CATCH	
	No.	%
Water Temp. (F)		
<60	26	1.3
60-62	223	11.0
>62	1790	87.8
TOTAL	2039	100.0

TABLE 10. Capture-recapture data on American shad tagged at the Conowingo Fish Lift, 15 April-15 June 1982.

SPECIES	TAGNO	TAG DATE	RECAPTURE DATE	FREE DAYS	YEAR TAGGED
14	14297	05/27/81	05/18/82	356	81
	20192	05/01/82	05/22/82	21	82
	20194	05/01/82	05/09/82	8	82
	20211	05/01/82	05/09/82	8	82
	20222	05/01/82	05/09/82	8	82
	20228	05/01/82	05/11/82	10	82
	20280	05/02/82	05/17/82	15	82
	20284	05/02/82	05/11/82	9	82
	20285	05/02/82	05/17/82	15	82
	20288	05/02/82	05/18/82	16	82
	20294	05/02/82	05/09/82	7	82
	20298	05/02/82	05/06/82	4	82
	20307	05/02/82	05/13/82	11	82
	20309	05/02/82	05/12/82	10	82
	20327	05/02/82	05/21/82	19	82
	20329	05/02/82	05/13/82	11	82
	20337	05/02/82	05/14/82	12	82
	20357	05/02/82	05/19/82	17	82
	20358	05/02/82	05/08/82	6	82
			05/16/82	14	82
	20369	05/02/82	05/16/82	14	82
	20381	05/02/82	05/11/82	9	82
	20387	05/02/82	05/08/82	6	82
	20436	05/03/82	05/21/82	18	82
	20447	05/03/82	05/09/82	6	82
			05/23/82	20	82
	20461	05/03/82	05/17/82	14	82
	20483	05/03/82	05/17/82	14	82
	20491	05/03/82	05/08/82	5	82
			05/18/82	15	82
	20677	05/06/82	05/31/82	25	82
	20682	05/06/82	05/18/82	12	82
	20690	05/06/82	05/12/82	6	82
	20698	05/06/82	05/18/82	12	82
	20708	05/06/82	05/16/82	10	82
	20712	05/06/82	05/21/82	15	82
	20734	05/06/82	05/17/82	11	82
	20748	05/06/82	05/23/82	17	82
	20754	05/06/82	05/22/82	16	82
	20778	05/07/82	05/11/82	4	82
	20835	05/09/82	05/25/82	16	82
	20864	05/09/82	05/26/82	17	82
	20872	05/09/82	05/19/82	10	82
	21046	05/10/82	05/22/82	12	82
	21065	05/11/82	05/21/82	10	82
	21330	05/16/82	05/31/82	15	82
	21587	05/22/82	05/31/82	9	82
	21593	05/22/82	05/31/82	9	82

TABLE 11. Summary of transportation of American shad from the Conowingo Fish Lift, 5 May-21 May 1982.

Date	No. Collected at Facility	Water Temp (F)	No. Transported	Location	Observed Mortality	% Survival
5 May*	37	61.4	36	Fort Hunter, PA	1	97
6 May	101	62.9				
7 May	18	62.8				
8 May**	172	64.5	75	Lapidum, MD	0	100
9 May	276	65.9	75	City Island, PA	1	99
			78	City Island, PA	17	78
10 May	17	64.7				
11 May	118	65.0	75	City Island, PA	2	97
12 May	50	65.0	45	City Island, PA	4	91
13 May	141	66.0	85	City Island, PA	8	91
15 May	NO OPERATION					
16 May	101	68.3	72	City Island, PA	0	100
17 May	121	66.8	57	City Island, PA	0	100
			45	City Island, PA	7	84
18 May	155	68.0	75	City Island, PA	0	100
			64	City Island, PA	2	97
19 May	40	70.0	36	City Island, PA	0	100
20 May	19	73.4				
21 May	132	72.5	50	City Island, PA	0	100
			49	City Island, PA	0	100
Totals	1521		917		42	95

* Transported by U.S. Fish Wildlife Service
** Test of circular transport system

97
75
172

842
5
847

80 - Live upstream

TABLE 12. Summary of transportation of blueback herring from the Conowingo Fish Lift, 13 May 1982.

Date	No. Collected at Facility	Water Temp (F)	No. Transported	Location	Observed Mortality	% Survival
13 May	4978	66.0	280	Broad Creek, MD	0	100
			450	Broad Creek, MD	0	100
Totals	4978		730		0	100

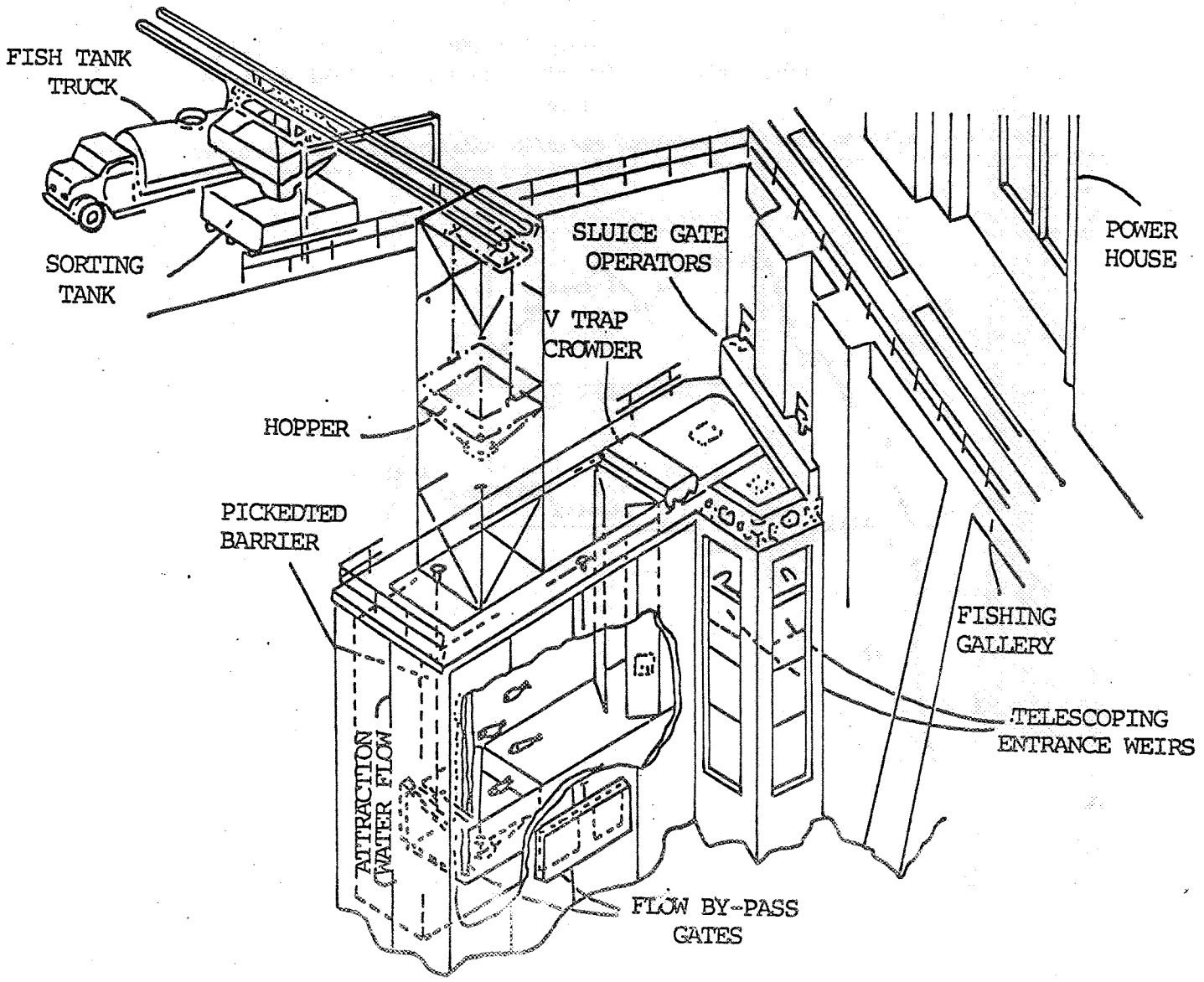


FIGURE 1

Schematic drawing of Conowingo Fish Lift, Anonymous (1972).

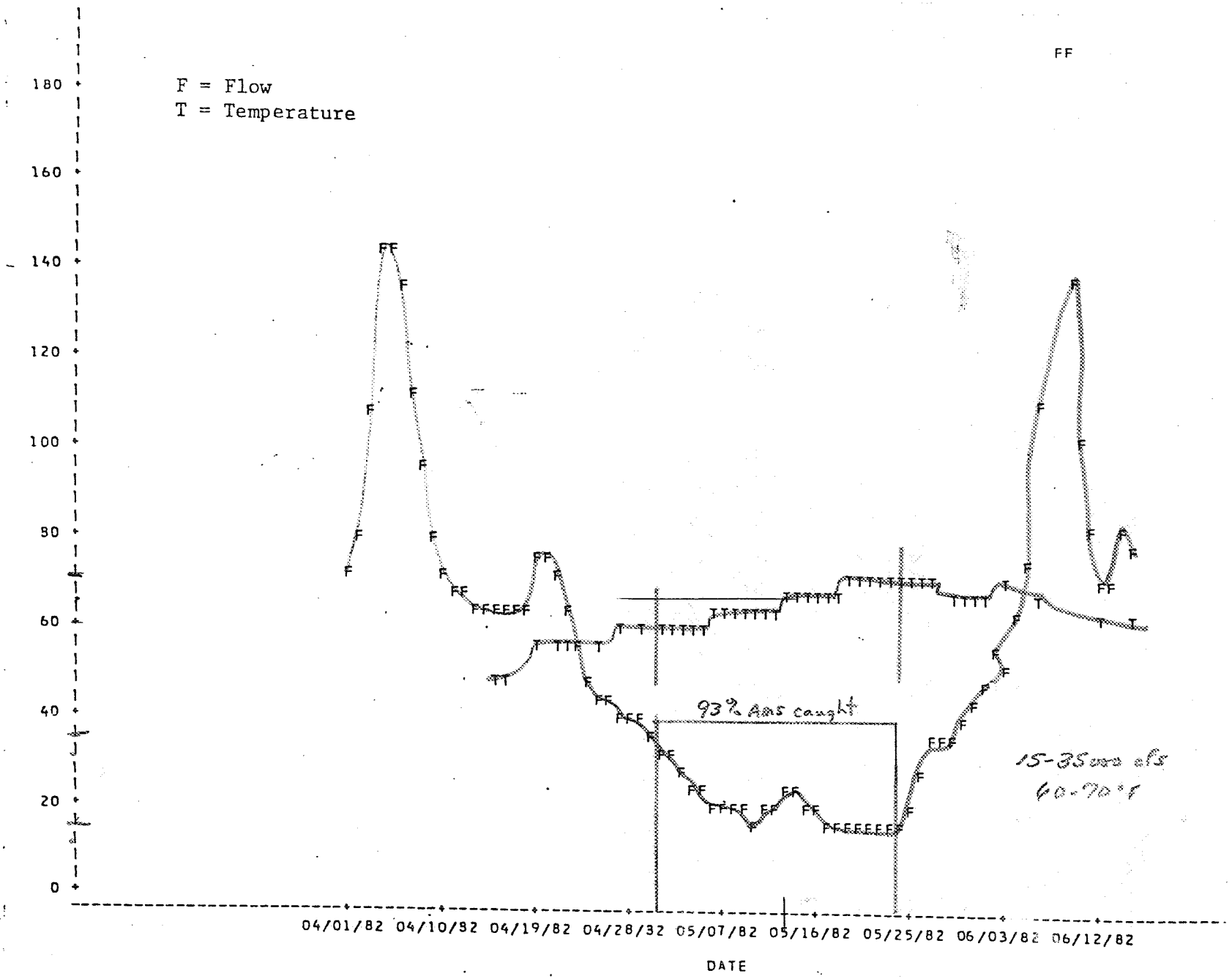


Figure 2. Daily river flows (1000 cfs) and water temperature (F) at Conowingo fish lift, April 1 - June 15, 1982.

Summary of catch by day and species at the Conowingo Fish Lift, 15 April-
15 June 1982.

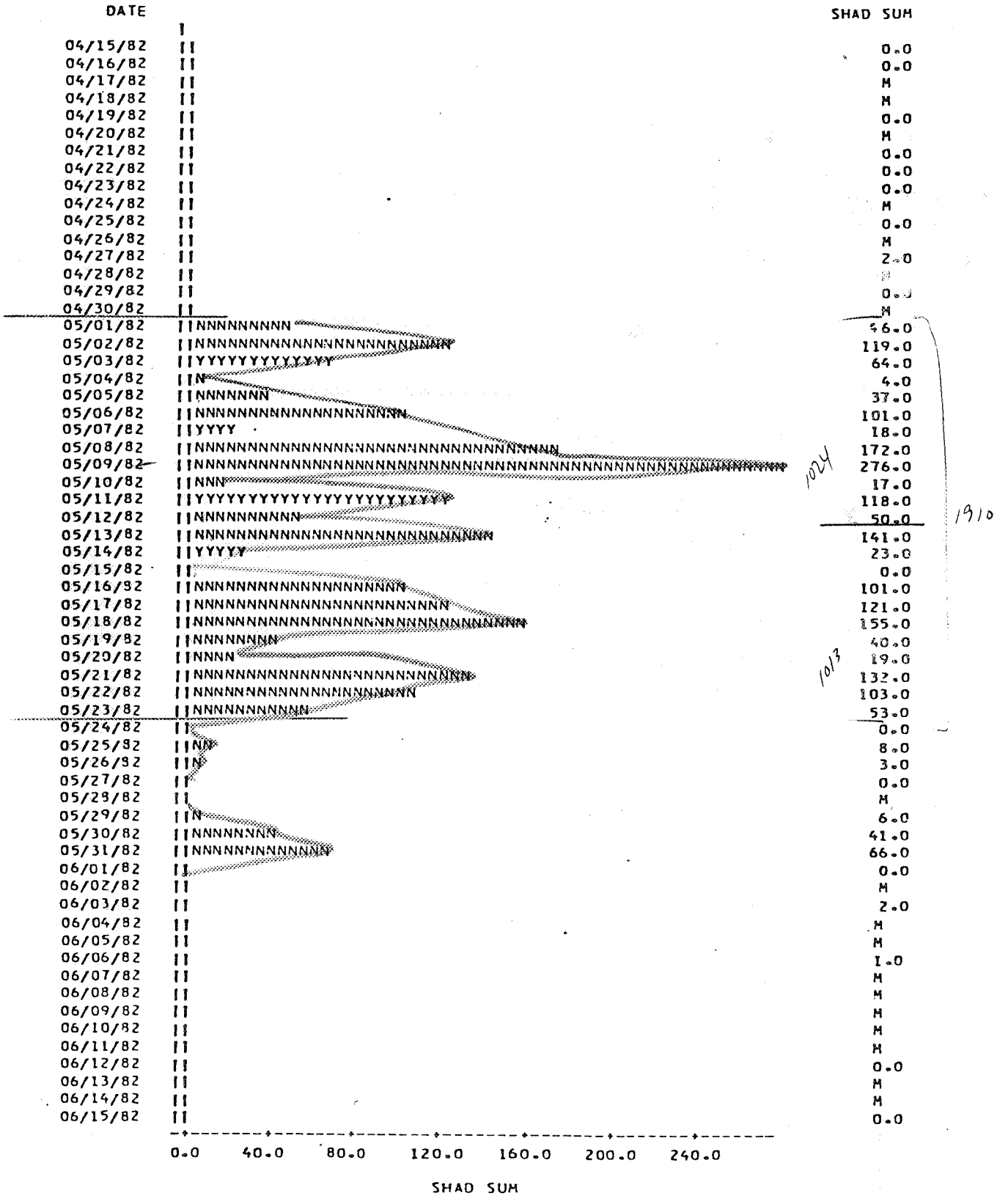
```
      DATE                                                                                           FISH SUM
             |
   04/15/82  |                                                                                          266.0
   04/16/82  |                                                                                          582.0
   04/17/82  |                                                                                              M
   04/18/82  |                                                                                              M
   04/19/82  |                                                                                         1174.0
   04/20/82  |                                                                                              M
   04/21/82  |G                                                                                        2010.0
   04/22/82  |GGG                                                                                      6658.0
   04/23/82  |GGG                                                                                      6521.0
   04/24/82  |                                                                                              M
   04/25/82  |GGGGGGGGGGGGGGGH                                                                        31543.0
   04/26/82  |                                                                                              M
   04/27/82  |GGGGGGGGGGGGGGGGGGGGGG                                                                  43418.0
   04/28/82  |                                                                                              M
   04/29/82  |FGGGGGGGGGGGGGGGGGGGGGGGGGG                                                             54422.0
   04/30/82  |                                                                                              M
   05/01/82  |GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGWW                       124845.0
   05/02/82  |GGGGGGGGGGGGGGGGGGGGGGGGG                                                               49214.0
   05/03/82  |GGGGGGGGGGGGGGW                                                                         30311.0
   05/04/82  |GGGGGGGGGGGGGGGW                                                                        32527.0
   05/05/82  |CFFGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGW                              111861.0
   05/06/82  |GGGGGGW                                                                                 15216.0
   05/07/82  |FGGGGGGGGGW                                                                             22554.0
   05/08/82  |GGGGGGGGGGGGGGGGGGGGGGGGGGW                                                             55500.0
   05/09/82  |GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGOWW                                                     70768.0
   05/10/82  |FGGGGGGGGGGWWW                                                                          29307.0
   05/11/82  |GGGGGGGGGGGGGGGHWW                                                                      35726.0
   05/12/82  |GGGGGGGGGGGGGGGHHHHHHHHWW                                                               52576.0
   05/13/82  |GGGGGGGGGGGGGGGHHW                                                                      37156.0
   05/14/82  |FGGGGGGGGGGGWW                                                                          28941.0
   05/15/82  |                                                                                          500.0
   05/16/82  |GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGHO                                                     71053.0
   05/17/82  |GGGGGGGGGGGGGGGG                                                                        32243.0
   05/18/82  |CGGGGGGGGGGGGGGGGGOW                                                                    39128.0
   05/19/82  |CGGGGGGGGGGGGOOW                                                                        32817.0
   05/20/82  |GGGGGGGGGGGO                                                                            24020.0
   05/21/82  |CGGGGGGGGGGGGGHOW                                                                       34093.0
   05/22/82  |GGGGGGGGGGGGGGOOOWW                                                                     37794.0
   05/23/82  |G                                                                                        3339.0
   05/24/82  |CGO                                                                                      5482.0
   05/25/82  |FFGG                                                                                     9497.0
   05/26/82  |FGGGGGGG                                                                                16690.0
   05/27/82  |FGGGGGGGO                                                                               17554.0
   05/28/82  |                                                                                              M
   05/29/82  |GGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGGG                                            87573.0
   05/30/82  |G                                                                                        3499.0
   05/31/82  |GG                                                                                       5143.0
   06/01/82  |CFFFGGGGGGGGGGGGGGGGGGGGGGG                                                             53699.0
   06/02/82  |                                                                                              M
   06/03/82  |FFGGGGGGGGGGGGGG                                                                        32889.0
   06/04/82  |                                                                                              M
   06/05/82  |                                                                                              M
   06/06/82  |FGGGGGGGGGG                                                                             21311.0
   06/07/82  |                                                                                              M
   06/08/82  |                                                                                              M
   06/09/82  |                                                                                              M
   06/10/82  |                                                                                              M
   06/11/82  |                                                                                              M
   06/12/82  |GGGGGGG                                                                                 14195.0
   06/13/82  |                                                                                              M
   06/14/82  |                                                                                              M
   06/15/82  |FGGGGGGGG                                                                               17559.0
             ----------+---------+---------+---------+---------+---------+--
                    20000.0   40000.0   60000.0   80000.0  100000.0  120000.0

                                          FISH SUM
```

SYMBOL	SPECIES	SYMBOL	SPECIES	SYMBOL	SPECIES	SYMBOL	SPECIES
		C	CARP	F	FCHANNEL CATFISH	G	GIZZARD SHAD
H	HERRING	O	OTHER	W	WHITE PERCH		

M Lift not operated

Summary of American shad catch by day at the Conowingo Fish Lift, 15 April-15 June 1982.



M--Lift not operated
Y - Morpholine used
N - Morpholine not used

1910
129
2039

FIGURE 5.

Summary of American shad catch by lift and time of day showing generation status of each of the main Units 1-11 (- indicates unit off) at the Conowingo Fish Lift, 8 May 1982.

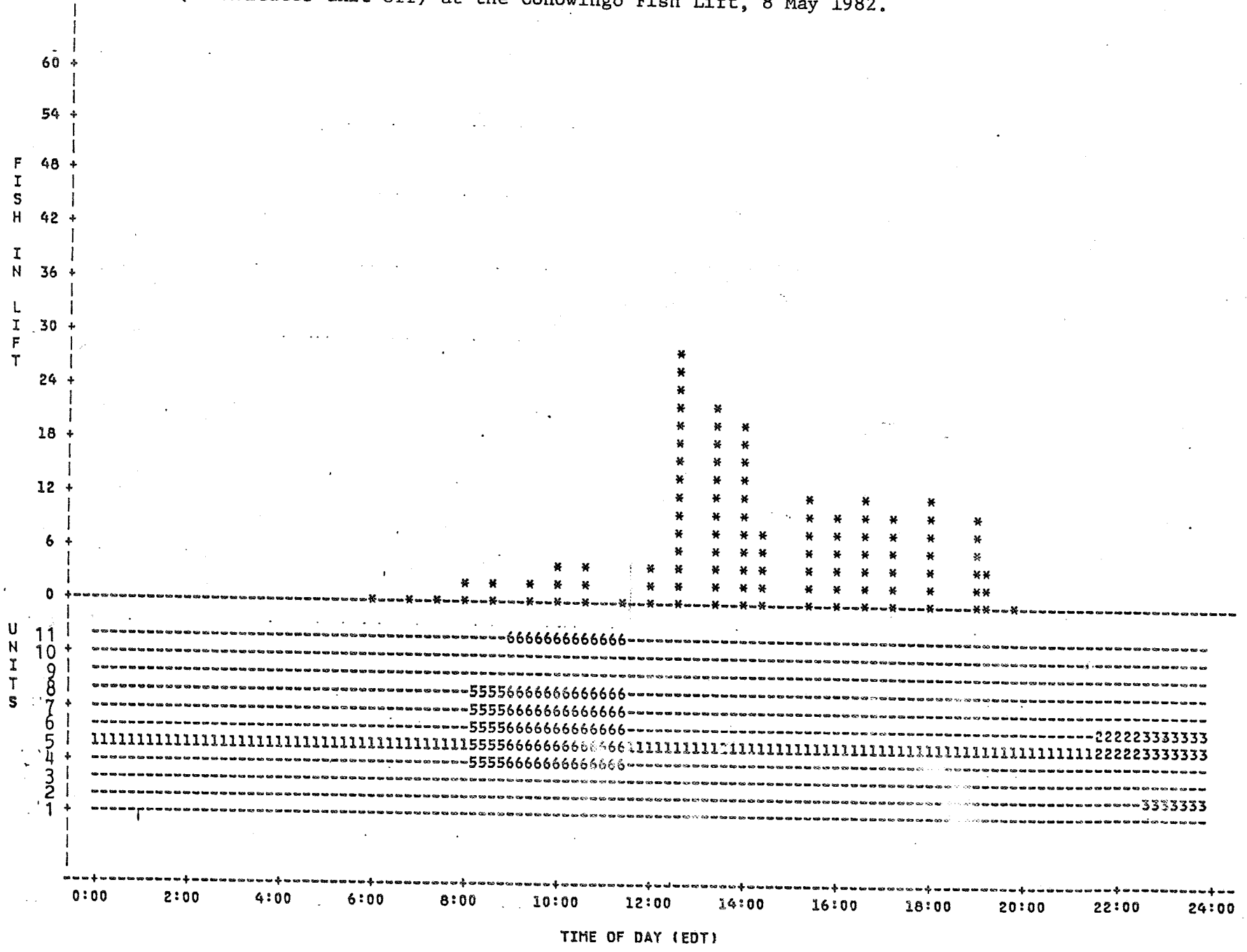


FIGURE 6.

Summary of American shad catch by lift and time of day showing generation status of each of the main Units 1-11 (- indicates unit off) at the Conowingo Fish Lift, 11 May 1982.

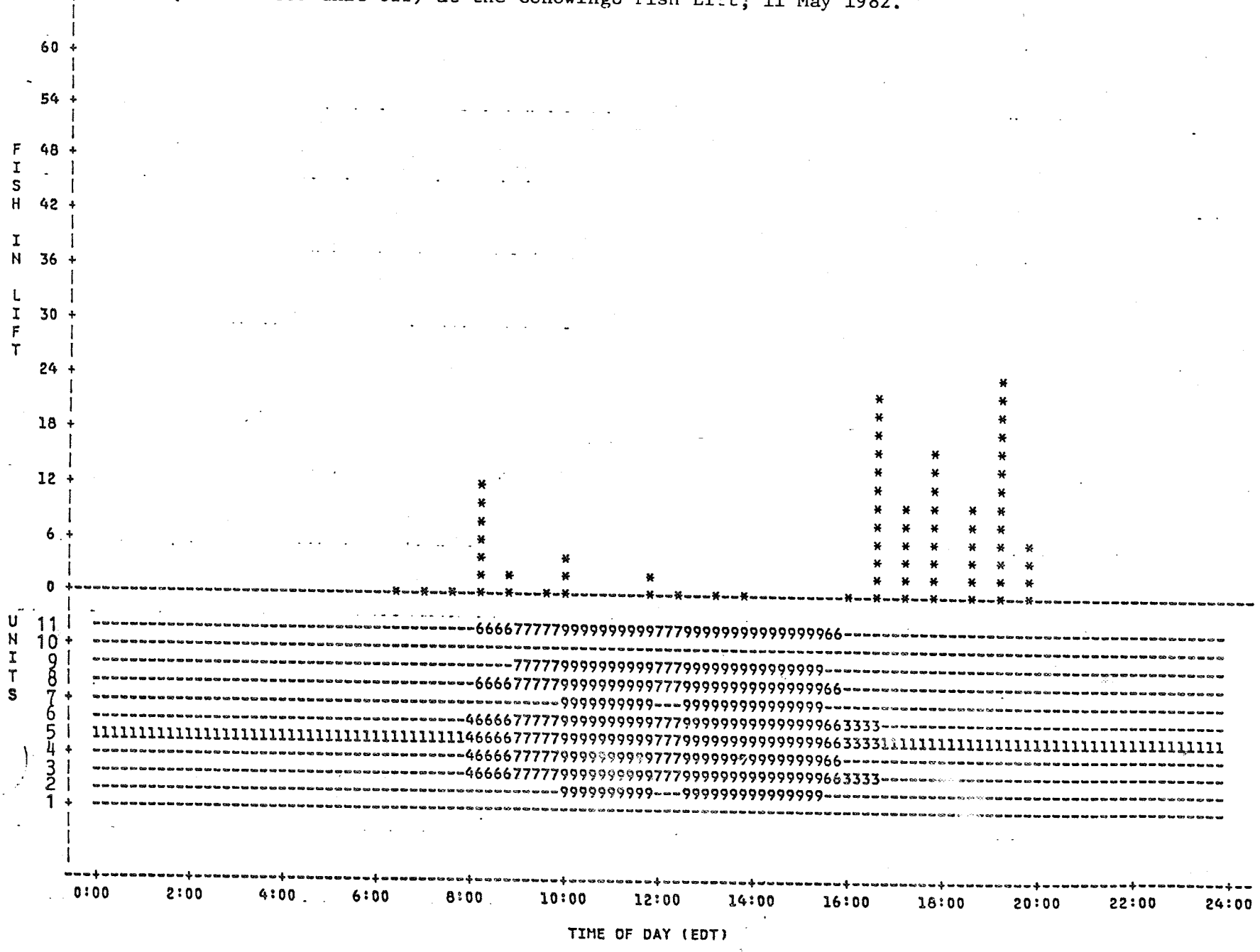
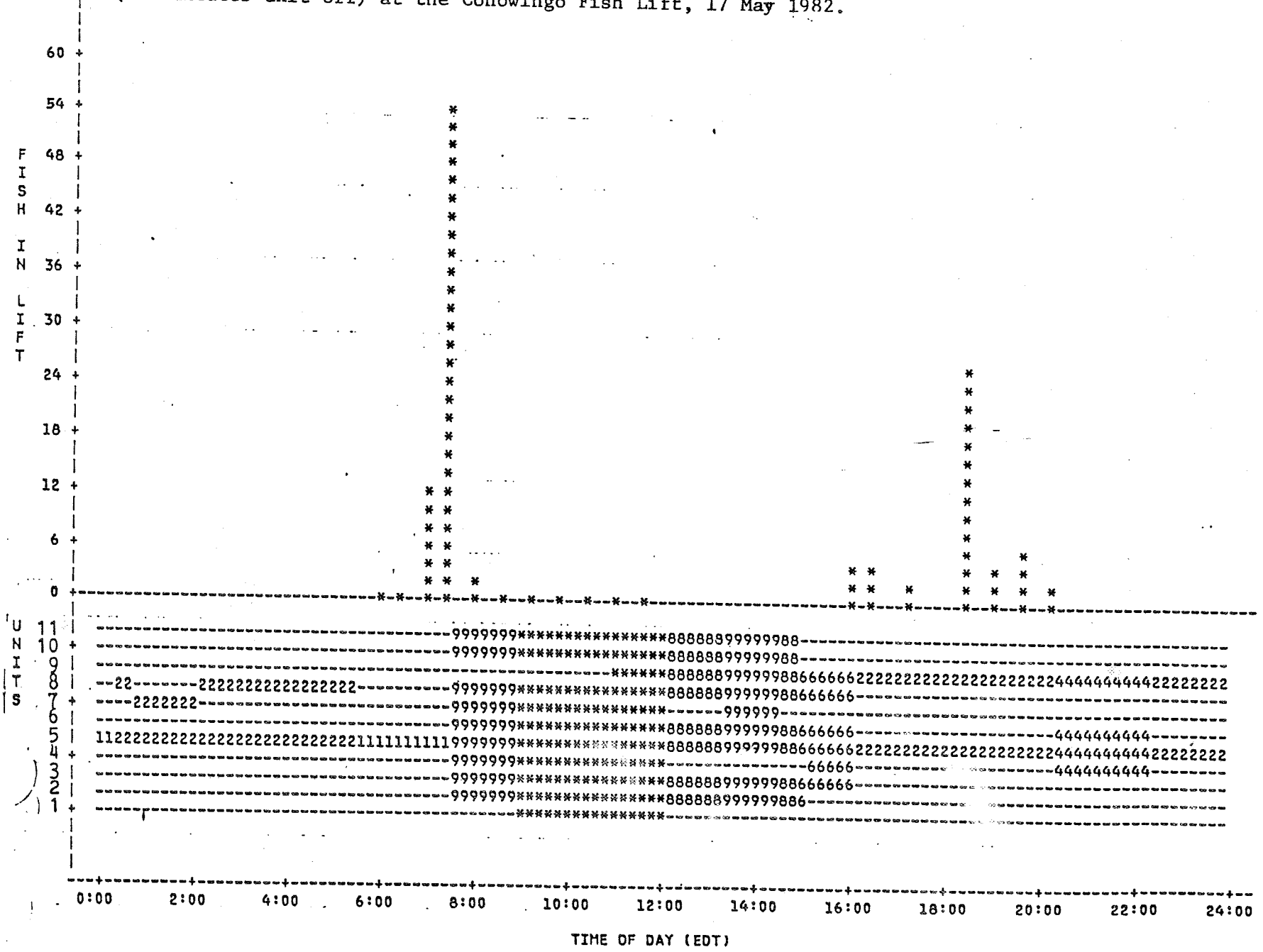


FIGURE 7.

Summary of American shad catch by lift and time of day showing generation status of each of the main Units 1-11 (- indicates unit off) at the Conowingo Fish Lift, 17 May 1982.



JOB VII. AMERICAN SHAD POPULATION ASSESSMENT, SPORTFISHING SURVEY AND JUVENILE RECRUITMENT SURVEY IN THE LOWER SUSQUEHANNA RIVER AND FLATS

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7.1 INTRODUCTION

Alosa sapidissima (Wilson), or more commonly, the American or white shad has been the target of commercial fisheries in the Maryland portion of the Chesapeake Bay for over 200 years. Reliable catch data was unavailable until 1880 when 3.7 million pounds of shad were reported (Mansueti and Kolb 1953). A decade later, 7.1 million pounds were landed. After 1890, the landings of shad began to decline. By 1909, the commercial catch was 3.2 million pounds, 45% of what it had been 20 years earlier, and catches were still decreasing. There were brief periods in which landings of American shad improved. These were associated with the post Depression - post war periods when commercial fishing held a low priority. Since that time, commercial landings have fluctuated around one million pounds, until 1970 when the catches declined drastically (Table 1). By 1979, only 46,000 pounds of American shad were caught in the Chesapeake Bay, 14,000 lbs. of which were from the Susquehanna River, the principle shad river in Maryland (Mansueti et al. 1953).

The causes for the overall decline in the shad harvest during the past 90 years include several factors which may or may not be working in unison: 1) overharvesting of the stock, 2) man-made barriers, and 3) pollution.

Only one of these factors could be controlled immediately by implementing

regulations. Hence, the Department of Natural Resources imposed a closure on the commercial and recreational American shad fisheries in 1980 (Md. Register 1980).

At this time, the Tidewater Administration of Maryland's Department of Natural Resources began a long term investigation into the presence and abundance of adult and juvenile American shad in the upper Chesapeake Bay. The objective of this study is to assess the head-of-the-bay shad stocks, specifically those utilizing the Susquehanna River below Conowingo Dam to the Susquehanna Flats. This study includes the following:

1) A spawning adult population estimate based upon a spring-time mark-recapture technique;

2) A population characterization - defining length and weight frequency distributions, sex ratios, age composition, and spawning history data;

3) Sportfishing survey - determining angling pressure, catch per unit of effort (CPUE), harvest and catch composition;

4) Juvenile recruitment survey - a summer-fall assessment of abundance by haul seine and otter trawl techniques for evidence of reproductive success of American shad.

7.2 METHODS AND MATERIALS

A) Tagging and Population Estimate

Tagging of adult American shad was undertaken at various sites within the Susquehanna River, Susquehanna Flats, and Northeast River. This part of the survey was conducted in early April to late May of each year during spawning runs. We obtained fish for tagging from commercial pound nets, anchor gill nets, and angling (Fig. 1). Angling, utilized in 1982 only, was done upriver near Conowingo Dam. Pound nets were fished every other day in the early part of the season, with seasonal temperature increases, the nets were fished every day.

Anchor gill netting was done at night between 2300 hrs and dawn. This was necessary because upriver nearer Conowingo Dam, the nets would only fish when flow through the dam was minimal. The nets were fished continuously so that American shad fatalities caused by stress would be minimized. As the fish were removed from the net, they were placed in a circular fiberglass tank, 48 in. diameter by 30 in. deep. A bilge pump created current into which the fish could orient themselves. Fish were then tagged and released well away from the netting area to avoid immediate recaptures. A $5.00 reward was offered for the return of the tag.

B) Population Characterization

During tagging, a sample of approximately a dozen scales were removed midway between the dorsal fin and the lateral line on the left side of each fish. Date, location of capture, net type, sex and length (mm) and weight (kg) of the shad were recorded. Weight measurements were taken from dead fish only. Gill net caught fish seemed to be more stressed than those obtained from pound nets. To avoid aggravating the risk of mortality, scale samples were not taken from fish taken and tagged from this gear type.

These scale samples were then prepared for age and spawning history evaluation. Four to six non-regenerated scales were selected and cleaned thoroughly in a mild solution of soap and water. An impression of these cleaned, dry scales was made on acetate slides by using a roller press. The slides were then placed in a microprojector and read at 2.5 X magnification. They were read by two biologists according to the techniques developed by Cating (1953) and verified by Judy (1961). If an age could not be agreed upon, the slide was set aside to be re-read. If agreement could not be reached upon reading a slide the second time, the slide was discarded.

C) Sportfishing Survey

The survey format used was a non-uniform probability creel census as described by Pfeiffer (1966). This format makes use of knowledge of prior fishing pressure on a particular body of water in order to assign sampling probabilities to the days of the week, time of day, and location of a particular sampling site. Information contained in Whitney (1961), Carter (1973), and RMC (1979) was instrumental in formulating the probabilities for twelve access points located on the lower Susquehanna River (Fig. 2). Day and time probabilities were recalculated to account for holidays. Interviews were conducted with anglers who had completed their fishing trips. Anglers were asked their mode of fishing, number in their party, state of residence, time spent fishing, species caught, and disposition of catch. These parameters were then expanded by the assigned probabilities in order to yield an estimate of fishermen usage, pressure, and catch for the area.

D) Juvenile Recruitment Survey

Nursery area sites (Fig. 3) were sampled for the presence of young-of-the-year American shad on a biweekly basis from July through October. Ten shallow water shore sites were sampled using haul seines during each biweekly period. At sites 1 through 7 and 10, a 200' X 10' X 1/2" mesh haul seine was paid out by boat in a semi-circular shape. Because of the rocky substrate in the Susquehanna River above Port Deposit, a 100' X 6' X 1/2" mesh haul seine proved to be more effective at sites 8 and 9.

Six trawl sampling stations were established in the Susquehanna Flats and Northeast River as close to the corresponding seine sites as water depth and favorable topography would permit. A semi-balloon otter trawl 16' head rope, 1 1/2" stretch mesh open end, 1 1/2" stretch cod end with a 1/2"

stretch mesh cod liner) was used to sample these open water stations. Both modes of sampling were performed nearly simultaneously with replicates being taken, except where precluded by inclement weather or equipment failure.

7.3 RESULTS

A) Population Estimate

Chapman's modification of the Petersen population estimate equation (Ricker 1975) was used to estimate the American shad spawner population in 1980, 1981, and 1982. The estimate for 1980 was calculated to be approximately 2,700 shad (95% Confidence level; lower limit = 1,607, upper limit = 4,740). In 1981, the adult shad population was estimated to be 5,500 individuals (95% CL; LL = 3,539, UL = 8,894).

Making the Petersen estimate involves utilizing the count of fish observed in the fish trap at Conowingo Dam. In 1980 and 1981, the method of operating that trap was relatively constant, but in 1982 it was altered. The catch of shad in the trap in 1982 increased seven fold. This materially affected the results of our population estimating technique. Whereas we had estimated some 2,700 and 5,500 fish in the two years previous, the 1982 estimate was approximately 33,000 American shad.

There is no realistic way to make an estimate of 1982 that reflects what would have been the result had trapping conditions remained constant. Nevertheless, we have roughly estimated that if the rate of population increase measured, between 1978-81 continued, the 1982 estimate would have been approximately 6,800 fish (MTA infile data).

Altering the operating schedule at Conowingo Dam seemed to greatly enhance the ability of the fish lift to capture American shad. It will be interesting to see whether future catches of American shad continue to increase under this new operating regime.

B) Population Characteristics

Currently, the state's management of American shad harvest is limited to a closure of the sport and commercial fisheries. This management does not depend upon analysis of the age and sex of the returning adults. We anticipate that in the future, management objectives will include optimization of the harvest by regulating the capture of selected age groups. This would direct fishing effort, by regulating mesh size, toward that age group or groups which best satisfy management objectives of such parameters as maximum net economic yield, maximum angler satisfaction, stock protection, etc.

Toward these ends, we are collecting population characterization data on age, sex, and spawning history for use as baseline information. To date, results from pound net caught fish (unbiased by size or sex) have been as follows (see Table 2);

1) The proportion of male shad in the migrating population has increased four fold since this project's inception.

2) A marked change in male age class structure has been observed. In 1981, age III individuals predominated, with ages IV and V contributing minimally. In 1982, the 1978 year class (of age IV) males again dominated the age class structure as seen in all three gear types (it is assumed that hook and line is a non-selective gear type).

From studies conducted on the Delaware River, Chittenden (1975) postulated that a sudden increase in the proportion of age III male American shad may be an indication of a relatively strong year class which may influence the size of future runs. This is so because males tend to reach sexual maturity

and enter the fishery one to two years before the female cohort.

Fewer repeat spawners in recent years may be attributed to; 1) failure of the virgin recruits to survive the first spawning, or 2) a large influx of these younger individuals into the migratory population which would affect the virgin: repeat spawner ratio.

Paucity of data precludes extensive analysis and characterization of American shad stocks of the Susquehanna River at this time. Continued sampling of sex ratios, age, and spawning history will strengthen our data base, which presently is our immediate goal.

C) Sportfishing Survey

Observed characteristics and estimates of total pressure, catch, and harvest for the lower Susquehanna River/Flats area are presented in Table 3. These data cover the creel surveys conducted in 1970, and 1979 through 1981 (Carter 1973, RMC 1979, Weinrich et al. 1981, Weinrich et al. in press, respectively). The 1970 data are included as a base line reference. A downward trend was noticed for all estimated parameters between 1970 and 1979. A longer census period in 1981 resulted in increased pressure estimates in 1981, with a concurrent 29% upsurge in overall estimated catch and a 50% increase in estimated harvest. Angling pressure per day, however, remained low, as did actual catch of fish per hour and actual fish kept per hour. In 1982, pressure estimates declined dramatically (MTA infile data). Both the number of anglers and the effort they expended dropped approximately 62% each as compared to 1981 figures. The estimated total catch, that is, all fish caught regardless of disposition, was 43% less than in 1981. A comparison of success rates and catch composition (expressed in percent) are shown in Table 4. Success rate is expressed as estimated number of fish caught per man-hour of effort expended.

Success rates for American shad and the combined herring species declined greatly between 1970 and 1979. In 1981, anglers were more successful in catching these species as demonstrated by the 10% increase in American shad CPUE (= success rate) and the 4% increase in herring CPUE compared to 1980. Preliminarily, in 1982 anglers were an additional 2.6% more successful in capturing American shad than in the previous year. Herring CPUE also rose slightly more than one percent (MTA infile data).

D) Juvenile Recruitment Survey

Maryland Tidewater Administration has conducted juvenile abundance surveys for striped bass since 1954, and has tabulated the abundance of other species collected in the same effort since 1958 (Boone 1981). This paper makes reference to tabulations made in 1962, since that date coincides with the reorganization of the commercial landings data line and because the number of regularly visited stations utilized in the juvenile index study has been constant since that date.

One of the four areas this survey directed its seining efforts has been the Head-of-the-Bay which includes the Susquehanna River, Susquehanna Flats, Elk River, Bohemia River, Sassafras River, and Worton Creek. Each station is sampled once monthly during July, August, and September.

There appeared to be a surprisingly strong run of adult American shad in the upper Bay this past Spring (1982). This would not have been suggested by the juvenile index values for American shad for the years 1977 through 1979 (Table 5). The apparent abundance could be related to Maryland's fishing closures over the last three years, to Pennsylvania's hatchery production, or both. It should be noted that many more shad than have been taken by the Conowingo trap in recent years have been caught this Spring (RMC 1979). To a large but unknown degree, this is a result of changes in

the methods of trap operation, as explained earlier.

In addition to the long-term survey, our juvenile survey has been directed in the Susquehanna River, Susquehanna Flats, and Northeast River. The effort expended in this survey is more intensive in that the stations are sampled biweekly. Table 6 shows the catch per seine haul and catch per trawl run (both CPUE's) of American shad, blueback and alewife herring (Alosa aestivalis and A. pseudoharengus), and striped bass (Morone saxatilis). Because our sampling for this year is not yet complete, it would be premature to draw any conclusions from these data. But the following trends seem to have developed:

1) The catch of blueback herring has improved for the 1982 survey as compared to 1981.

2) Alewife CPUE for both gear types is still decreasing.

3) Striped bass CPUE's have improved in 1982 as compared to the past two years.

4) One juvenile American shad has been collected.

In 1968 - 69, a low number of young shad (530 fish (Carter 1973) were captured in that juvenile survey as compared to the number of adults which produced them (Table 1). It would be unlikely that American shad would be caught during the current survey, considering the numbers seen in 1968 - 69, which resulted from more abundant spawners.

7.4 SUMMARY

1) The population estimates for American shad utilizing the Susquehanna River/Flats areas each year over the past three years were approximately 2,700 (1980), 5,500 (1981), and a range of 6,800 to 33,000 individuals in 1982.

2) An increase in the proportion of adult male shad in the migrating population has been observed during the course of our survey.

3) Although estimates of angler pressure and total catch of fishes have been decreasing, incidences of American shad captures are becoming more numerous.

4) One young-of-the-year American shad was captured in our 1982 juvenile recruitment surveys.

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Table 7.1 Recent commercial landings of anadromous fish in Upper Chesapeake Bay.* (thousands of pounds).

Year	Striped Bass	American Shad	Hickory Shad	River Herring	White Perch	Total
1962	4,708	1,771	14	13,384	2,109	21,986
1963	4,357	963	11	9,495	1,424	16,250
1964	4,100	1,287	18	9,460	703	15,568
1965	3,978	1,627	19	12,025	1,529	19,177
1966	4,166	1,281	9	12,558	1,911	19,925
1967	4,502	1,014	7	10,562	1,342	17,427
1968	4,978	1,245	7	12,404	1,941	20,575
1969	5,396	1,292	20	6,874	2,184	15,766
1970	4,145	1,208	46	8,213	1,793	15,405
1971	3,034	1,126	11	8,642	1,587	14,400
1972	3,460	1,152	27	7,369	1,174	13,182
1973	5,550	714	47	4,023	820	11,154
1974	4,123	260	12	4,881	540	9,816
1975	3,149	239	16	6,312	558	10,274
1976	2,215	158	5	1,404	487	4,269
1977	2,451	102	1	617	717	3,898
1978	1,495	114	1	1,591	1,190	4,391
1979	1,106	46	1	1,130	776	3,059
1980	2,427	34[1]	0	789	1,063	4,313
1981	1,956	4[1]	0[2]	152	752	2,864

* Maryland Chesapeake Bay plus Virginia's Potomac River landings;

1 Maryland's commercial and sport seasons closed; Md.'s 1979 landings 34,000 lb.

2 Maryland's commercial and sport seasons closed.

Table 7.2 Age frequency, number and percent repeat spawners by sex for American shad as collected by pound net in the Susquehanna Flats during 1980,1981, and 1982.

Year	Proportion	Number	Age Group				Percent Repeat Spawners
			III	IV	V	VI	
A. Males							
1980	0.78	47	10	23	12	2	19.1
1981	2.79	39	21	18			2.6
1982	3.30	181	28	114	37	2	4.0
B. Females							
1980	1.00	60		38	20	2	6.7
1981	1.00	14		7	7		7.1
1982	1.00	50		28	20	2	0.0

Table 7.3a. Characteristics of samples for Susquehanna River and Flats creel censuses of 1970, and 1979-1982.

Parameter	1970	1979	1980	1981	1982
Survey dates	3/28-6/21	4/28-6/30	5/3-6/28	4/4-6/25	4/3-6/23
No. Interview days	34	29	27	37	35
No. Interviewed anglers	1607	937	749	1320	1105
Hours fished	8314	3462	3668	5436	4275
Hours/interview day	244.52	119.38	135.85	146.92	127.03
Mean trip length (hrs)	5.17	4.10	5.03	3.90	3.68
Catch (No. fish)	7738	3886	4741	4570	5567
Catch/hour (no. fish)	0.93	1.12	1.29	0.84	1.30
Kept/Hour (no. fish)	0.57	0.45	0.55	0.38	0.38
% anglers non-resident	49.1	20.0	24.6	17.2	16.3

Table 7.3b. Estimates derived from Susquehanna River and Flats creel censuses of 1970, and 1979-1982.

Parameter	1970	1979	1980	1981	1982
Total anglers (trips)	56,977	26,291	21,602	49,741	18,172
Total hours fished	291,510	106,530	109,764	177,799	67,653
Total catch (no. fish)	377,611	120,434	129,611	166,779	93,601
Total harvest (no. kept)	205,280	48,914	50,432	75,936	30,103

Table 7.4. Success rates and percentage of catch by species for Susquehanna River and Susquehanna Flats creel censuses of 1970 and 1979-1982

Species	Success Rate (no. caught per man-hour)					% of total catch			
	1970	1979	1980	1981	1982	1970	1979	1980	1981
A. sapidissima	0.0835	0.0043	0.0003	0.0031	0.0080	8.96	0.8	0.0	0.0
A. mediocris	0.0172	0.0	0.0	0.0	0.0	1.84	0.0	0.0	0.0
A. pseudoharengus + A. aestivalis	0.2609	0.0295	0.0016	0.0068	0.0080	28.03	3.0	0.0	5.3
M. americana	0.3842	0.6912	0.7375	0.3571	0.8550	41.26	54.9	47.1	47.6
M. saxatalis	0.0404	0.0517	0.1270	0.0217	0.0170	4.34	3.7	17.8	1.1
I. punctatus	0.0593	0.1944	0.1892	0.1727	-	6.37	22.6	16.2	36.3
I. nebulosus + I. natalis	0.0172	-	0.0725	-	-	1.84	-	7.4	-
Micropterus spp.	0.0093	0.0182*	0.0164*	0.0177*	-	0.88	1.0*	1.2*	0.7*
C. carpio	trace	0.0589	0.0744	0.0576	-	trace	6.9	6.5	2.1
				TOTALS		93.53	92.90	96.2	93.1

* smallmouth bass only

Table 7.5 Annual mean values of relative abundance for young-of-the-year of five species of anadromous fish in the Head of Chesapeake Bay, Maryland.*

Number caught per haul of a 100'x4'x½" stretched mesh seine.

Year	Alosa aestivalis	Alosa pseudoharengus	Alosa sapidissima	Morone saxatilis	Morone americana	Total
1962	56.2	20.4	4.8	11.3	17.9	110.6
1963	51.6	6.3	0.8	6.1	28.5	[illegible]
1964	27.2	0.6	0.4	31.0	28.6	87.8
1965	10.8	2.7	0.2	2.1	14.1	29.9
1966	27.5	15.7	8.7	32.4	24.8	109.1
1967	85.1	4.8	0.7	17.4	5.3	113.3
1968	79.1	0.3	2.6	13.1	27.4	122.5
1969	743.0	10.1	2.0	25.7	90.3	871.1
1970	27.3	100.9	0.8	33.1	77.7	239.8
1971	16.3	13.7	0.9	23.7	42.9	97.7
1972	5.5	1.7	0.3	12.1	13.9	33.5
1973	11.8	2.5	0.0	24.4	12.1	50.8
1974	0.0	1.1	0.0	19.8	3.7	24.6
1975	0.5	13.2	0.0	7.6	10.5	31.9
1976	0.4	2.3	0.0	9.9	5.5	18.1
1977	0.3	7.3	0.0	12.1	16.2	35.9
1978	36.7	3.7	0.0	12.5	32.0	84.9
1979	1.0	2.7	0.0	9.1	14.5	27.4
1980	0.1	3.2	0.0	2.3	19.4	25.0
1981	0.0	3.9	0.0	0.3	7.3	11.5
20 year average	59.03	10.9	1.11	15.3	24.6	110.9
Average, minus extremes	24.3	6.4	0.8	15.1	22.2	74.2

* Data taken from Federal Aid Project F-27-R. Striped bass investigation.

Table 7.6 CPUE (Catch per unit of Effort) of five commercially and recreationally important species collected in the Susquehanna River/Flats juvenile surveys conducted in 1980, 1981, and 1982.

Species	Trawl			Seine		
	1980	1981	1982	1980	1981	1982
Alosa sapidissima	0.0	0.0	0.01	0.0	0.0	0.0
A. aestivalis	0.3	0.0	0.1	0.7	tr	0.8
A. pseudoharengus	0.4	0.4	0.1	1.2	0.8	0.1
Morone saxatilis	0.1	0.0	0.5	0.4	0.1	1.4
M. americana	-	-	10.1	-	-	37.8

tr = trace

Figure 7.1 Present (▲) and former (△) gill net stations and present (●) and former (○) pound net stations in the Upper Chesapeake Bay.

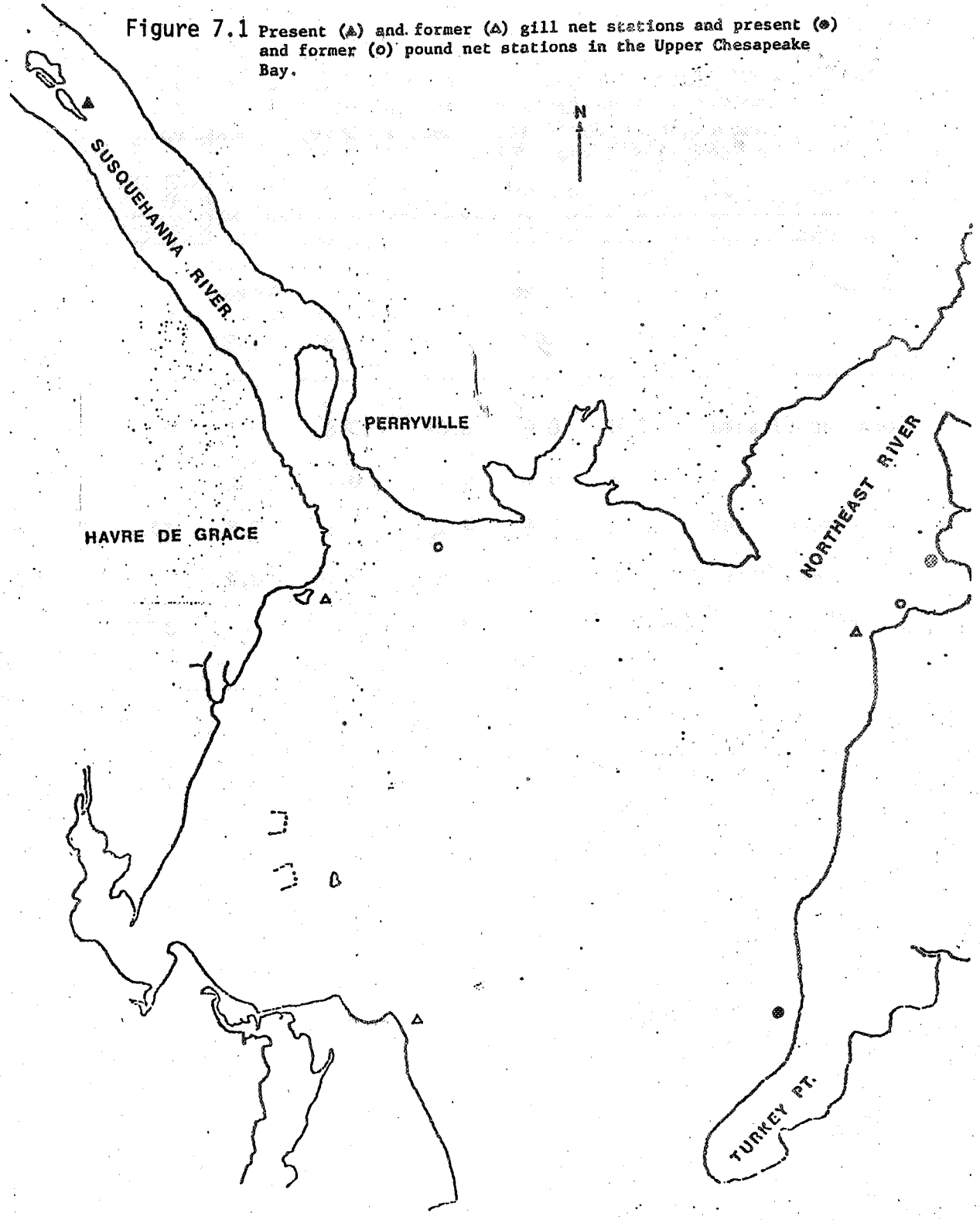
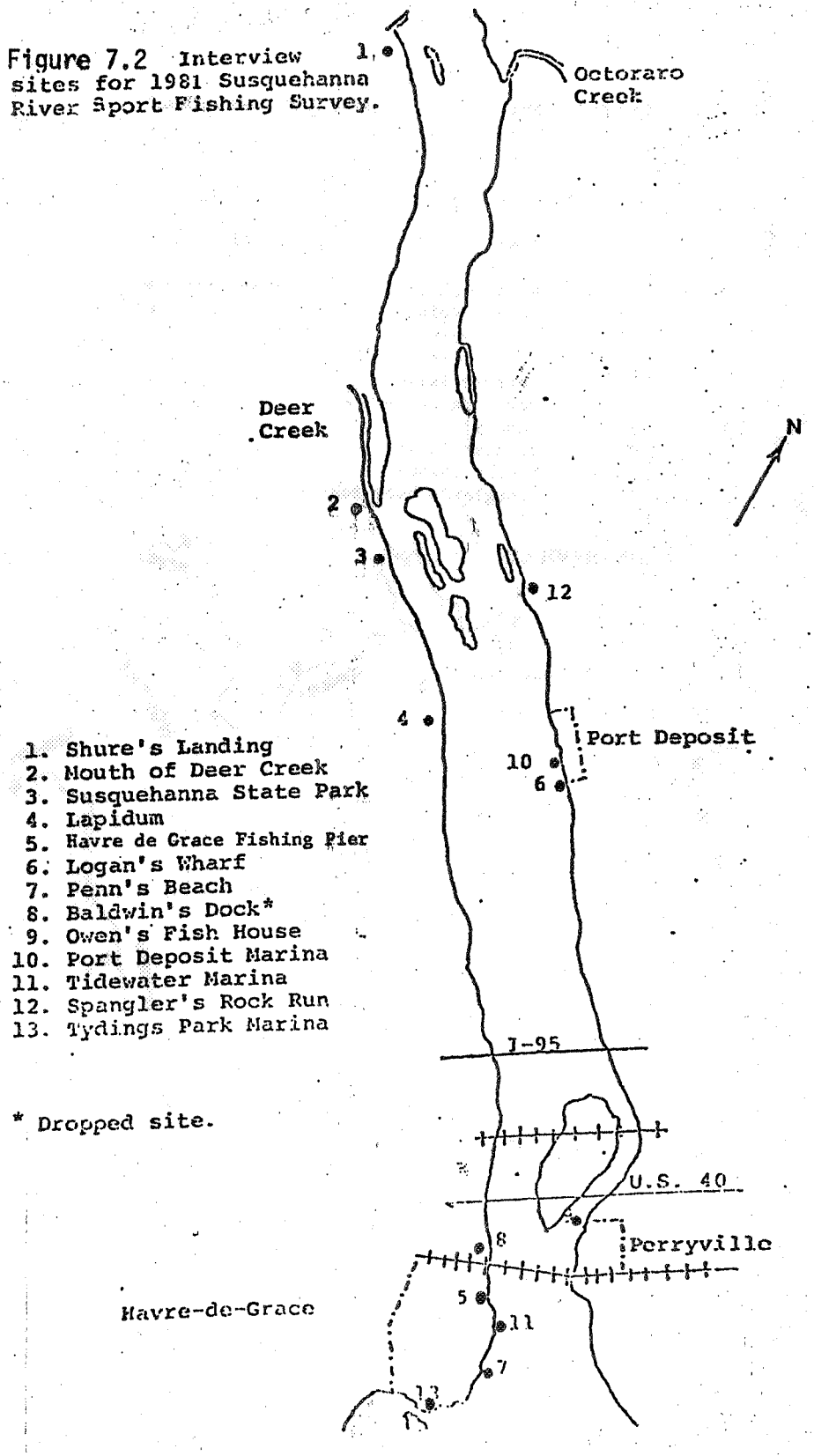


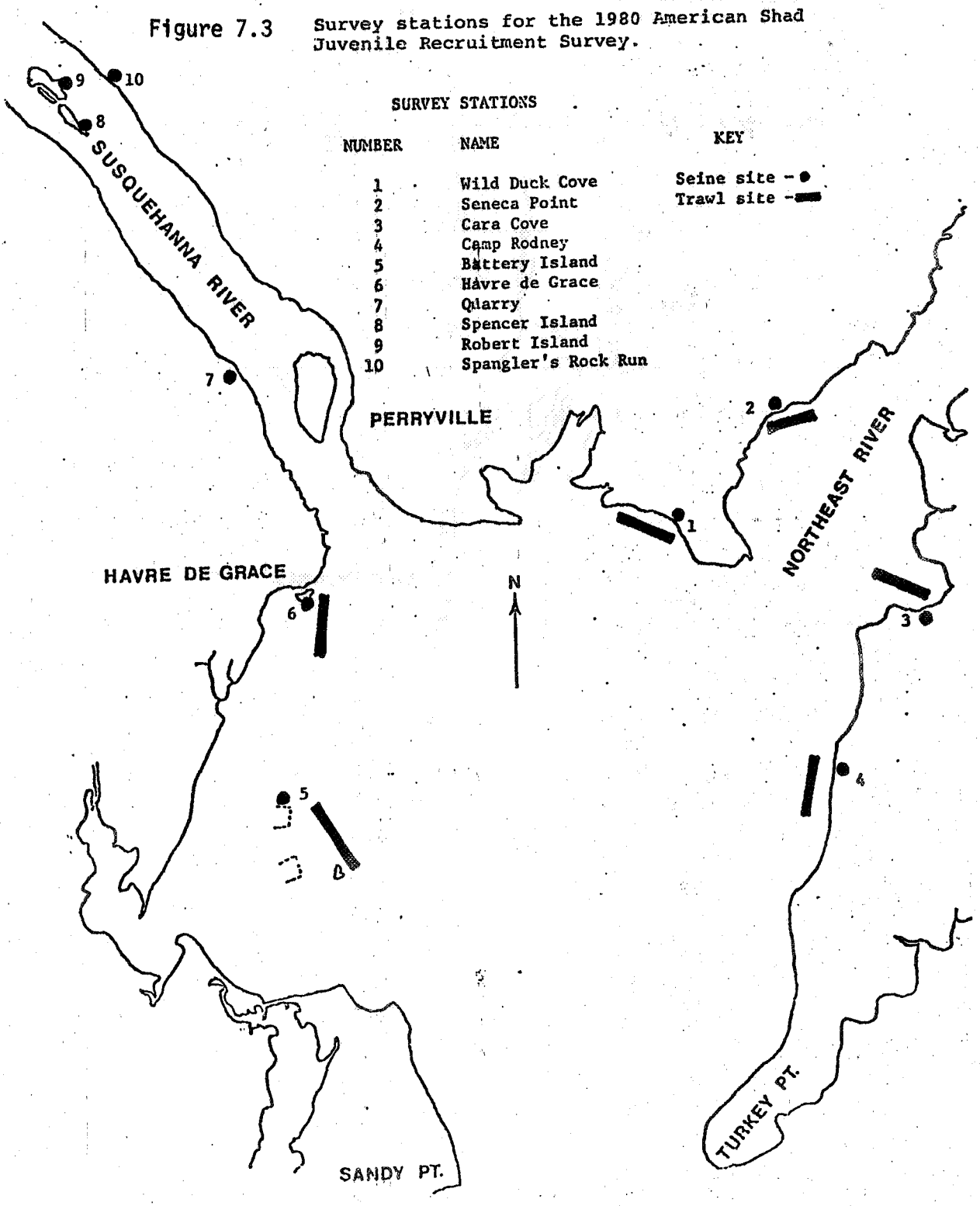
Figure 7.2 Interview sites for 1981 Susquehanna River Sport Fishing Survey.



1. Shure's Landing
2. Mouth of Deer Creek
3. Susquehanna State Park
4. Lapidum
5. Havre de Grace Fishing Pier
6. Logan's Wharf
7. Penn's Beach
8. Baldwin's Dock*
9. Owen's Fish House
10. Port Deposit Marina
11. Tidewater Marina
12. Spangler's Rock Run
13. Tydings Park Marina

* Dropped site.

Figure 7.3 Survey stations for the 1980 American Shad Juvenile Recruitment Survey.



APPENDIX 7A. COMPUTATIONS, NOTES, AND COMPARISON OF DATA FOR RECENT YEARS

Preliminary Results of the 1982 Investigation of American Shad in the Upper Chesapeake Bay

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I. POPULATION ESTIMATION

The estimated number of adult American shad utilizing the upper Chesapeake Bay during 1982 was calculated according to the following formula:

1. Chapman's Modification of the Pertersen Index -

$$N = \frac{(M + 1)(C + 1)}{R + 1}$$

where N = population estimate
M = No. fish tagged
C = No. fish examined
R = No. tagged fish recaptured

2. N for the following years -

1980 = 2,675 (LL = 1,607 ; UL = 4,740)
1981 = 5,477 (LL = 3,539 ; UL = 8,894)
1982 = see below

Treatment I: Utilize the entire shad catch at the Conowingo fish trap plus Tidal Fisheries non-tagged fish for estimate of C

where M = 339
R = 21
C = 1,985 + 82 = 2,067

therefore $N = \frac{(339 + 1)(2,067 + 1)}{21 + 1}$

= 31,960 (LL = 21,307; UL = 50,223)

NOTE: A Shaeffer Estimate of the 1982 shad population using recaptures from the Conowingo trap and Tidewater collections was 33,742.

Treatment II: Utilizing only Tidal Fisheries non-tagged fish for estimate of C -

therefore $N = \frac{(339 + 1)(82 + 1)}{21 + 1}$

= 1,283 (LL = 855; UL = 2,016)

Treatment III: estimate the 1982 Conowingo Fish Trap shad catch based on a linear regression of the 1978-1981 Trap catch to project the 1982 value of C

YEAR	TRAP CATCH	
1978	55	
1979	50	
1980	135	
1981	317	
1982*	357	(projection of 357 with $r^2 = .81$)

Therefore- $$N = \frac{(339 + 1)\ (357 + 82 + 1)}{21 + 1}$$

$$= 6,800 \quad (LL = 4,533 \quad UL = 10,686)$$

3. The estimate for Treatment I, 31,960, is quite likely too high for the following reasons;

   a) Significant changes in the operation of the Conowingo Fish Trap occurred during 1982 and it was felt by the Trap operators that this was the major reason for the six fold increase in the shad catch by this gear.

   b) The large increase in the number of tagged adults for 1982 over 1981 (339 vs 245) was because of the large increase in the number of hook and line captured individuals. This capture technique was not utilized in 1981 but proved to be most successful in 1982. If the number of hook and line tagged fish (81) is subtracted from the 1982 total, then the difference is only 13 more fish for this year.

   c) Analysis of the Tidal Fisheries catch per unit of effort for collecting taggable adults for the three years of this study further suggests that the estimate of Treatment I is in error. The following data are presented to support this contention:

YEAR	GEAR TYPE	CPUE
1980	pound net	1.07
	gill net	274
1981	pound net	0.87
	gill net	258
1982	pound net	0.92
	gill net	337

Pound net CPUE is as numerical catch per pound net day while that for gill net is in average square yard hours needed to catch one shad.

Key Points: 1982 vs 1981
- population estimate of 31,960 is tenuous because of the major changes in Fish Trap operation in 1982
- catch/effort data indicates similar population trends for both years
- the success of hook and line tagging greatly increased the number of adults successfully marked

II. ADULT POPULATION CHARACTERIZATION

The following information was collected from adult shad captured during the 1982 upper Chesapeake Bay tagging operation:

A.

VARIABLE	NUMBER OF FISH OBSERVED		
	male	female	total
sex	324	99	423
length	323	99	422
weight	61	24	85
age	181	50	231
sex ratio	3.3	1	

B. Length/Weight Data:
male - ave. length = 417mm (16.5 in.)
ave. weight = 1.49kg (3.28 lbs.)
female - ave. length = 454mm (18.1 in.)
ave. weight = 1.93kg (4.25 lbs.)

C. Age/Spawning Data:

SEX	AGE GROUP					NUMBER
	III	IV	V	VI	T	REPEATS
male	28	114	37	2	181	8
female	0	28	20	2	50	0

% repeat spawners = 3.0

D. Key Points: 1982 vs 1981
- strong shift in sex ratio from strong female to very strong male
- average length and weight of male shad substantially greater in 1982
- average weight of females greater in 1982
- no change in % of repeat spawners

III. SPORT ANGLER SURVEY.

The following information was gathered from interviews with sport anglers fishing the lower Susquehanna River below Conowingo Dam from April 8 to June 23, 1982.

A. Catch/Effort Data:

estimated anglers = 18,172
estimated hours fished = 57,653
estimated catch = 93,601

B. Estimated Sport Catch of American Shad For:

1980 = 8
1981 = 118
1982 = 266

C. Catch Per Angler Hour and Hours To Catch One Fish

	1981		1982	
SPECIES	CPAH	HTC	CPAH	HTC
white perch	0.438	2.3	0.855	1.2
channel catfish	0.169	5.9	0.155	6.5
striped bass	0.027	36.9	0.017	59.2
herring	0.009	117.7	0.008	123.5
American shad	0.003	256.4	0.008	123.5

D. Key Points:

1982 vs 1981

- significant increase in the sport catch of American shad (125% increase)
- marked decline in striped bass success
- decrease in overall sport angler pressure (17%) and total catch (6%)

IV. JUVENILE RECRUITMENT SURVEY

A comparison of the 1982 juvenile survey with those of past years is presented below. These data compare total catch and catch per unit of effort for haul seine and otter trawl for five important sport and commerical finfish species. The 1982 data includes information from 19 bi-weekly sampling periods that began during the first week of July and continued through the last week of October. One young of the year American shad was captured during the 1982 juvenile survey. This fish was captured by otter trawl at Station 6 (Tydings Park) on October 28 (Sampling Period IX).

A. Juvenile Catch Comparisons

SPECIES	GEAR TYPE	1979 Total	1979 CPUE	1980 Total	1980 CPUE	1981 Total	1981 CPUE	1982 Total	1982 CPUE
blueback herring	hs	352	3.1	108	0.6	2	0.01	130	0.79
	ot	-	-	27	0.3	0	0.0	8	0.08
alewife herring	hs	18	0.2	194	1.1	108	0.8	14	0.09
	ot	-	-	38	0.4	33	0.4	14	0.13
white perch	hs	643	5.4	1,315	7.2	174	1.3	1,660	10.12
	ot	-	-	1,453	14.4	347	3.8	3,973	37.84
striped bass	hs	82	0.7	55	0.3	8	0.1	25[illegible]	1.43
	ot	-	-	8	0.1	0	0.0	49	0.47
American shad	hs	3	0.03	0	0.0	0	0.0	0	0.0
	ot	-	-	0	0.0	0	0.0	1	0.01

B. Supplemental Night Sampling:

In addition to the regularly scheduled juvenile daytime sampling effort a supplemental night haul seining operation was conducted during the summer of 1982. This extra effort took place the "off week" from the regular day sampling and was limited to sampling the seven lower seine sites on the Susquehanna River, Susquehanna Flats, and the Northeast River. Preliminary analysis of this night sampling indicated quite similar catch composition with the daytime operation. Both efforts have failed to captured any young-of-the-year American shad.

C. Because of high winds on September 1, 1982 the scheduled juvenile sampling had to be cancelled with only one haul seine pull completed. Because continued high winds precluded our return to sampling until the following week, it was decided to restart Period V thus eliminating this one particular seine pull. It should be noted, however, that on this particular seine haul we captured 374 blueback herring and 80 alewife herring. Based on all the data collected during the 1982 survey it seems reasonable to conclude that this large catch of alosids came from a single large school that congregated at the Wild Duck Cove site because of the prevailing weather conditions at the time. Inclusion of this large catch would bias the catch per effort and standing crop calculations for these species unrealistically distorting their apparant abundance.

D. Key Points

1982 vs 1981

- 1 juvenile shad captured in 1982
- juvenile herring catches still at the very low levels observed during 1981
- juvenile catch of striped bass and white perch up substantially over 1981